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Graph Neural Network Acceleration with SODA Framework

Master of Science Thesis in
Computer Science and Engineering

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Abstract

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Abstract in lingua italiana

Qui va l'Abstract in lingua italiana della tesi seguito dalla lista di parole chiave.

Parole chiave: qui, vanno, le parole chiave, della tesi

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Introduction

Introduction here

1 Background

Background here...

2 Conclusions and future developments

Final chapter containing the main conclusions of my research and possible future developments.

Bibliography

- [1] S. Abi-Karam, Y. He, R. Sarkar, L. Sathidevi, Z. Qiao, and C. Hao. Gengnn: A generic FPGA framework for graph neural network acceleration. *CoRR*, abs/2201.08475, 2022. URL <https://arxiv.org/abs/2201.08475>.
- [2] N. B. Agostini, S. Curzel, J. J. Zhang, A. Limaye, C. Tan, V. Amatya, M. Minutoli, V. G. Castellana, J. Manzano, D. Brooks, G.-Y. Wei, and A. Tumeo. Bridging python to silicon: The soda toolchain. *IEEE Micro*, 42(5):78–88, 2022. doi: 10.1109/MM.2022.3178580.
- [3] A. Auten, M. Tomei, and R. Kumar. Hardware acceleration of graph neural networks. In *2020 57th ACM/IEEE Design Automation Conference (DAC)*, pages 1–6, 2020. doi: 10.1109/DAC18072.2020.9218751.
- [4] A. Bik, P. Koanantakool, T. Shpeisman, N. Vasilache, B. Zheng, and F. Kjolstad. Compiler support for sparse tensor computations in MLIR. *ACM Transactions on Architecture and Code Optimization*, 19(4):1–25, sep 2022. doi: 10.1145/3544559. URL <https://doi.org/10.1145%2F3544559>.
- [5] U. Bondhugula. High performance code generation in MLIR: an early case study with GEMM. *CoRR*, abs/2003.00532, 2020. URL <https://arxiv.org/abs/2003.00532>.
- [6] S. Böhm. How to optimize a cuda matmul kernel for cublas-like performance: a worklog, 2022. URL <https://siboehm.com/articles/22/CUDA-MMM>.
- [7] L. He. Engn: A high-throughput and energy-efficient accelerator for large graph neural networks. *CoRR*, abs/1909.00155, 2019. URL <http://arxiv.org/abs/1909.00155>.
- [8] W. Hu, M. Fey, M. Zitnik, Y. Dong, H. Ren, B. Liu, M. Catasta, and J. Leskovec. Open graph benchmark: Datasets for machine learning on graphs. In H. Larochelle, M. Ranzato, R. Hadsell, M. Balcan, and H. Lin, editors, *Advances in Neural Information Processing Systems*, volume 33, pages 22118–22133. Curran Associates, Inc., 2020. URL https://proceedings.neurips.cc/paper_files/paper/2020/file/fb60d411a5c5b72b2e7d3527cfc84fd0-Paper.pdf.

- [9] Y. Hu, Y. Du, E. Ustun, and Z. Zhang. Graphlily: Accelerating graph linear algebra on hbm-equipped fpgas. In *2021 IEEE/ACM International Conference On Computer Aided Design (ICCAD)*, pages 1–9, 2021. doi: 10.1109/ICCAD51958.2021.9643582.
- [10] K. Kinningham, C. Ré, and P. A. Levis. GRIP: A graph neural network accelerator architecture. *CoRR*, abs/2007.13828, 2020. URL <https://arxiv.org/abs/2007.13828>.
- [11] T. N. Kipf and M. Welling. Semi-supervised classification with graph convolutional networks. *CoRR*, abs/1609.02907, 2016. URL <http://arxiv.org/abs/1609.02907>.
- [12] S. Liang, C. Liu, Y. Wang, H. Li, and X. Li. Deepburning-gl: an automated framework for generating graph neural network accelerators. In *2020 IEEE/ACM International Conference On Computer Aided Design (ICCAD)*, pages 1–9, 2020.
- [13] B. Sanchez-Lengeling, E. Reif, A. Pearce, and A. B. Wiltschko. A gentle introduction to graph neural networks. *Distill*, 2021. doi: 10.23915/distill.00033. <https://distill.pub/2021/gnn-intro>.
- [14] Z. Wu, S. Pan, F. Chen, G. Long, C. Zhang, and P. S. Yu. A comprehensive survey on graph neural networks. *CoRR*, abs/1901.00596, 2019. URL <http://arxiv.org/abs/1901.00596>.
- [15] K. Xu, W. Hu, J. Leskovec, and S. Jegelka. How powerful are graph neural networks?, 2019.
- [16] M. Yan, L. Deng, X. Hu, L. Liang, Y. Feng, X. Ye, Z. Zhang, D. Fan, and Y. Xie. Hygcn: A GCN accelerator with hybrid architecture. *CoRR*, abs/2001.02514, 2020. URL <http://arxiv.org/abs/2001.02514>.

A Appendix A

If you need to include an appendix to support the research in your thesis, you can place it at the end of the manuscript. An appendix contains supplementary material (figures, tables, data, codes, mathematical proofs, surveys, . . .) which supplement the main results contained in the previous chapters.

B Appendix B

It may be necessary to include another appendix to better organize the presentation of supplementary material.

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List of Symbols

Variable	Description	SI unit
u	solid displacement	m
u_f	fluid displacement	m

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