

Efficient MLIR Compiler Design: Vectorization for Presburger Library

Zhou Qi



4th Year Project Report
Computer Science
School of Informatics
University of Edinburgh
2023

Abstract

MLIR provides a presburger library that helps cache analysis and loop optimization. This library uses linear programming of simplex method and a core function is pivot, it performs two multiplication and one addition to every elements in a matrix. The input matrices have these characteristics: small value, low dimensionality and high sparsity. We can exploits these features and utilize modern micro-architectural-level hardware resources to accelerate the process.

The current source code in MLIR is a nested for-loop iterating every number in the matrix in a transprecision manner, where each number can be `int64_t` or `LargeInteger`. If overflow occurs when using `int64_t`, the algorithm will be redirected to `LargeInteger`. A better implementation is to have 3 layers of transprecision: (1) manually-vectorized `int16_t`, (2) manually-vectorized 52-bits integer (`int52_t`) represented using `double` and (3) `LargeInteger`.

Maybe explain reason for these choice? Say how to do overflow check: `int16` use saturated add, `int52` use SIGFPE

Another question: how detail should abstract be?

It is expected to have 4x? and 8x? performance improvement by vectorizing it and by introducing `int16_t` respectively. In practice the performance of the test has been increased by ? and the pivot function is ? x faster.

Research Ethics Approval

Instructions: *Agree with your supervisor which statement you need to include. Then delete the statement that you are not using, and the instructions in italics.*

Either complete and include this statement:

This project obtained approval from the Informatics Research Ethics committee.

Ethics application number: ???

Date when approval was obtained: YYYY-MM-DD

[If the project required human participants, edit as appropriate, otherwise delete:]

The participants' information sheet and a consent form are included in the appendix.

Or include this statement:

This project was planned in accordance with the Informatics Research Ethics policy. It did not involve any aspects that required approval from the Informatics Research Ethics committee.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(Zhou Qi)

Acknowledgements

Any acknowledgements go here.

Table of Contents

1	Introduction	1
1.1	Modern CPU micro-architecture	1
1.2	Citations	1
2	Your next chapter	2
3	Conclusions	3
3.1	Final Reminder	3
	Bibliography	4
A	First appendix	5
A.1	First section	5
B	Participants' information sheet	6
C	Participants' consent form	7

Chapter 1

Introduction

```
\begin{preliminary}  
...  
\end{preliminary}
```

1.1 Modern CPU micro-architecture

Computer architecture textbooks often deceive

1.2 Citations

Citations (such as [1] or [2]) can be generated using BibTeX. For more advanced usage, we recommend using the natbib package or the newer biblatex system.

These examples use a numerical citation style. You may use any consistent reference style that you prefer, including “(Author, Year)” citations.

Chapter 2

Your next chapter

A dissertation usually contains several chapters.

Chapter 3

Conclusions

3.1 Final Reminder

The body of your dissertation, before the references and any appendices, *must* finish by page 40. The introduction, after preliminary material, should have started on page 1.

You may not change the dissertation format (e.g., reduce the font size, change the margins, or reduce the line spacing from the default single spacing). Be careful if you copy-paste packages into your document preamble from elsewhere. Some L^AT_EX packages, such as `fullpage` or `savetrees`, change the margins of your document. Do not include them!

Over-length or incorrectly-formatted dissertations will not be accepted and you would have to modify your dissertation and resubmit. You cannot assume we will check your submission before the final deadline and if it requires resubmission after the deadline to conform to the page and style requirements you will be subject to the usual late penalties based on your final submission time.

Bibliography

- [1] Hiroki Arimura. Learning acyclic first-order horn sentences from entailment. In *Proc. of the 8th Intl. Conf. on Algorithmic Learning Theory, ALT '97*, pages 432–445, 1997.
- [2] Chen-Chung Chang and H. Jerome Keisler. *Model Theory*. North-Holland, third edition, 1990.

Appendix A

First appendix

A.1 First section

Any appendices, including any required ethics information, should be included after the references.

Markers do not have to consider appendices. Make sure that your contributions are made clear in the main body of the dissertation (within the page limit).

Appendix B

Participants' information sheet

If you had human participants, include key information that they were given in an appendix, and point to it from the ethics declaration.

Appendix C

Participants' consent form

If you had human participants, include information about how consent was gathered in an appendix, and point to it from the ethics declaration. This information is often a copy of a consent form.