Evaluating Two Approaches to Automated Code Refactoring

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Content Overview

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SAMURAI Application Code Overview
- SAMURAI code performs data assimilation on observational data
- **Spline Analysis at Mesoscale Using Radar & Aircraft Instrumentation**
ORIGINAL VERSION
- Developed at Colorado State University
- Written in C++ with OpenMP directives
- Was very expensive to run (1 to 3 days to run on single node)
- Initially CPU only

CURRENT VERSION
- Its optimized version with fast operators
- GPU enabled with OpenAcc directives
- Runs a lot faster. About 10-20 minutes.
Project Scope
Project Scope

- How to reduce cost of pencil calculation routines?
- How to integrate CUDA for SAMURAI application code?
How to reduce cost of pencil calculation routines?

How to integrate CUDA for SAMURAI application code?
Problem 1 - How to reduce cost of pencil calculation routines?

What is Pencil Calculation?

3D Matrix: 4 x 3

Gather 1D vector

Compute & Scatter 1D vector
Problem 1 - How to reduce cost of pencil calculation routines?

Approach: Polyhedral Optimization

- It's the method for automatically optimizing and parallelizing sequential programs through static analysis.

1. Program analysis
2. Applying transformation
3. Code generation
Problem 1 - How to reduce cost of pencil calculation routines?

Approach: Polyhedral Optimization

“Program Analysis”: intend to construct the dataflow graphs.

\[
\begin{align*}
(k = 0; & \ k < k\text{Dim}; \ k++) \\
\{ & \\
\text{tmp } +& = \text{kGammaL}[\text{KINDEX}(k\text{Dim} \cdot m + k, k\text{RankMax}\cdot k\text{Dim}, \text{var})] \cdot \text{kB}[k]; \\
\}
\end{align*}
\]
Problem 1 - How to reduce cost of pencil calculation routines?

Approach: Polyhedral Optimization

For “Program Analysis” : Constructed dataflow graph
Problem 1 - How to reduce cost of pencil calculation routines?

Approach : Polyhedral Optimization

- Program Analysis
  - intended to construct the dataflow graphs
  - dataflow graph not efficiently handling complexity of pencil calculation subroutine
  - time constraint issue to continue further

- Apply Transformation

- Code Generation
Project Scope

How to reduce cost of pencil calculation routines?

How to integrate CUDA for SAMURAI application code?
Problem 2 - How to integrate CUDA for SAMURAI application code

Approach : CUDA Programming

- Parallel computing platform and programming model for GPU

- Steps to implement -
  1. Learn CUDA programming
  2. Write a sample CUDA program
  3. Implement the CUDA for targeted code section
Problem 2 - How to integrate CUDA for SAMURAI application code

Approach: CUDA Programming

- **Steps to implement -**
  - Learn CUDA programming
    - NVIDIA articles
    - Udemy Tutorial
  - Write a sample CUDA program
  - Implement the CUDA for targeted SAMURAI code section
Problem 2 - How to integrate CUDA for SAMURAI application code

Approach: CUDA Programming

- Steps to implement -
  - Learn CUDA programming
  - Write a sample CUDA program
    - For understanding how to handle c++ & cuda dataflow
    - A test case to implement computational pattern similar to SAMURAI code.
  - Implement the CUDA for targeted SAMURAI code section
Problem 2 - How to integrate CUDA for SAMURAI application code

Approach: CUDA Programming

- Steps to implement -
  - Learn CUDA programming
  - Write a sample CUDA program
  - Implement the CUDA for targeted SAMURAI code section
    - choose a part of subroutine to run on gpu
    - wrote the kernel code for that section and linked it to original code
    - build the code for CPU and collected the results.
    - build the code for GPU and its giving the similar results as the CPU version, it requires further optimization
Problem 2 - How to integrate CUDA for SAMURAI application code

Approach : CUDA Programming

Steps to implement -
✓ Learn CUDA programming
✓ Write a sample CUDA program
✓ Implement the CUDA for targeted SAMURAI code section
Conclusion
Conclusion

**How to reduce cost of pencil calculation routines?**

We need to improve our handling of complex dataflow graphs to better accommodate complex codes like Samurai.

**How to integrate CUDA for SAMURAI code application?**

Additional work needed to better understand how to convert existing OpenACC code to CUDA model.
Further work needed on performance analysis and optimization.
**Polyhedral Optimization**

We need to improve our handling of complex dataflow graphs to better accommodate complex codes like Samurai.

**CUDA Programming**

Additional work needed to better understand how to convert existing OpenACC code to CUDA model.

Further work needed on performance analysis and optimization.
Thank You

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