Evaluating Two Approaches to Automated Code Refactoring

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Content Overview

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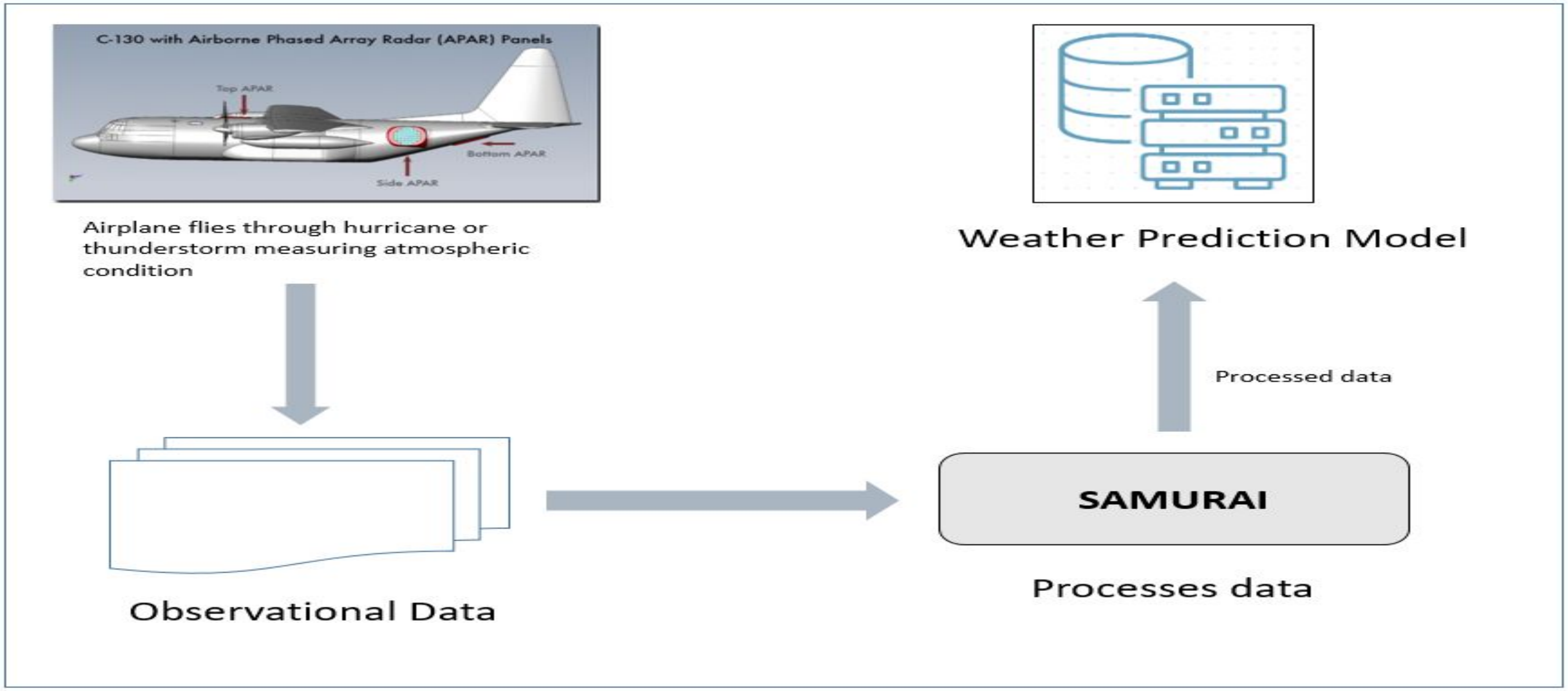
SAMURAI Application Code Overview

SAMURAI Application Code Overview

❑ SAMURAI code performs data assimilation on observational data

❑ **S**pline **A**nalysis at **M**esoscale **U**sing **R**adar & **A**ircraft **I**nstrumentation



Airplane flies through hurricane or thunderstorm measuring atmospheric condition

Observational Data

SAMURAI

Processes data

Processed data

Weather Prediction Model

SAMURAI Code Overview (contd..)

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?

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- How to reduce cost of pencil calculation routines?

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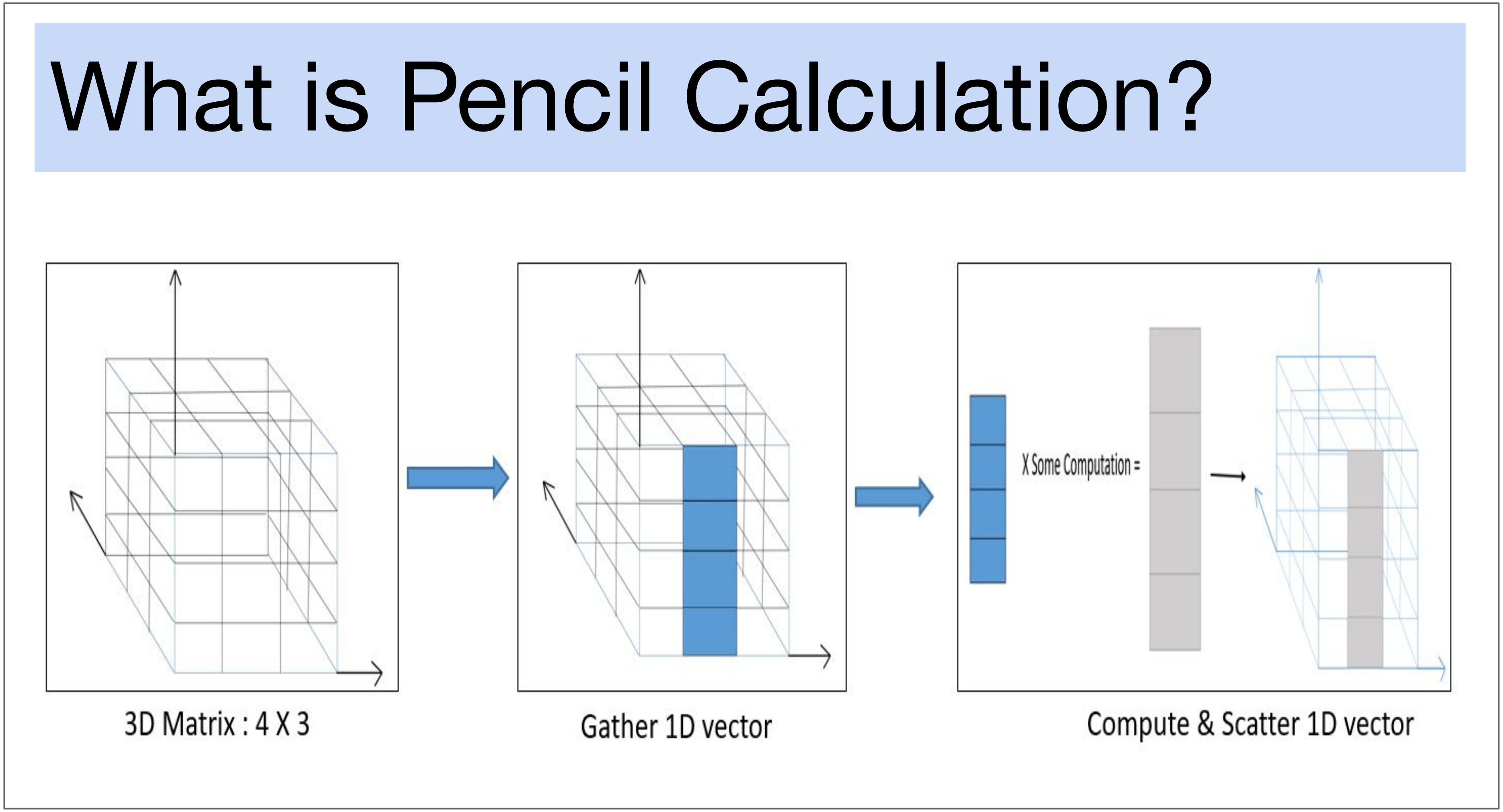
Problem 1 - How to reduce cost of pencil calculation routines?



What is Pencil Calculation?

3D Matrix : 4 X 3

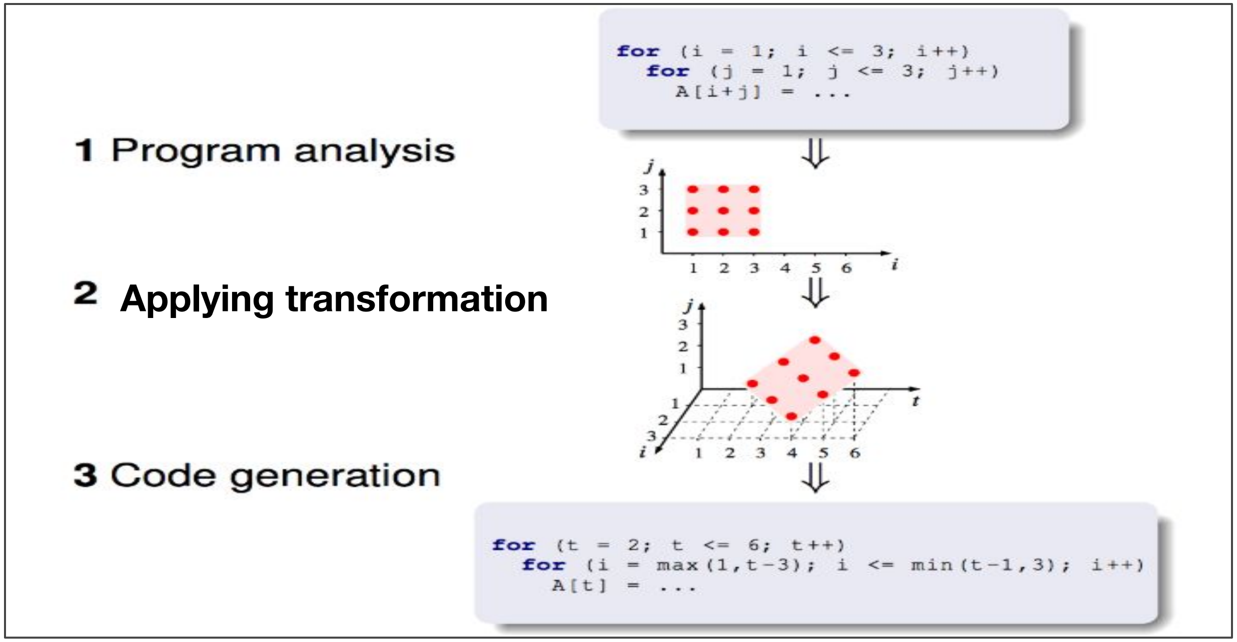
Gather 1D vector

Compute & Scatter 1D vector

Problem 1 - How to reduce cost of pencil calculation routines?

Approach : Polyhedral Optimization

- ❑ Its the method for automatically optimizing and parallelizing sequential programs through static analysis



```
for (i = 1; i <= 3; i++)
  for (j = 1; j <= 3; j++)
    A[i+j] = ...
```

1 Program analysis

2 Applying transformation

3 Code generation

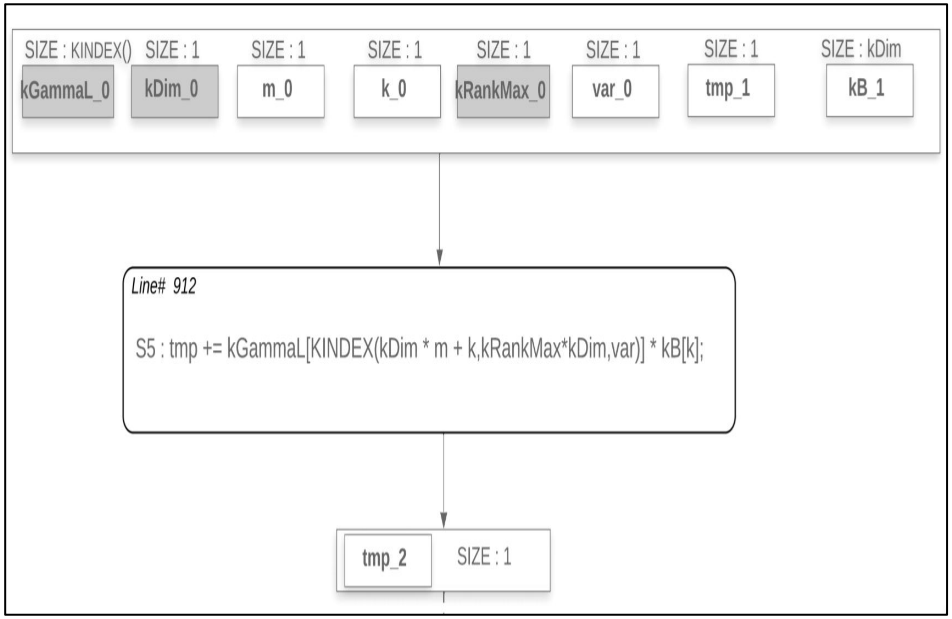
```
for (t = 2; t <= 6; t++)
  for (i = max(1,t-3); i <= min(t-1,3); i++)
    A[t] = ...
```

Problem 1 - How to reduce cost of pencil calculation routines?

Approach : Polyhedral Optimization

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

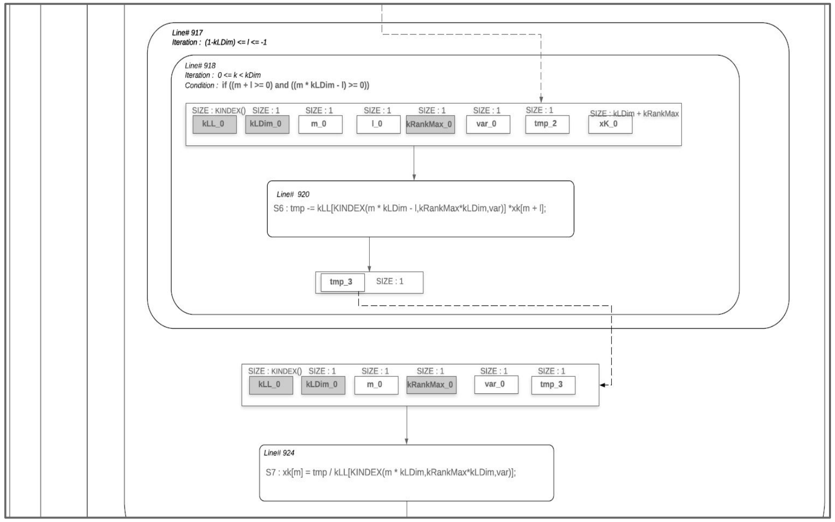
```
(k = 0; k < kDim; k++)
{
   tmp += kGammaL[KINDEX(kDim * m +
             k,kRankMax*kDim,var)] * kB[k];
}
```



Problem 1 - How to reduce cost of pencil calculation routines?

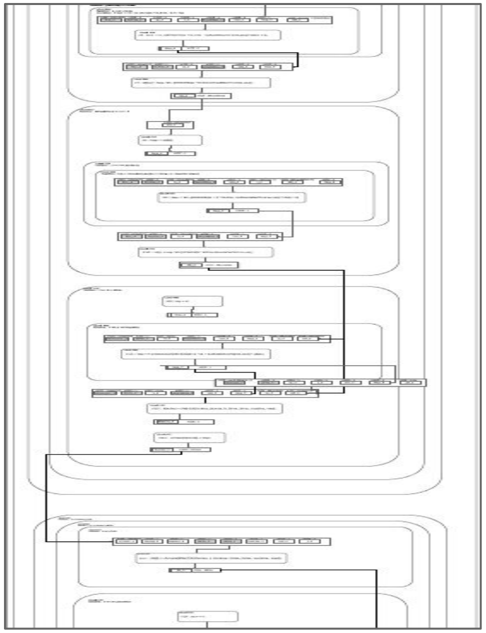
Approach : Polyhedral Optimization

- For "Program Analysis" : Constructed dataflow graph



```
S6 : tmp -= kLL[KINDEX(m * kLDim - l,kRankMax*kLDim,var)] *xk[m + l];
```

```
S7 : xk[m] = tmp / kLL[KINDEX(m * kLDim,kRankMax*kLDim,var)];
```



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

Conclusion

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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