Visualization for Program Behaviors

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Abstract

As HPC simulations grow more complex, debugging and optimizing them become vastly more difficult. This makes it necessary to design visualization tools that help developers understand the behavior of their applications. We propose novel visualizations and effective mechanisms to interact with them to support developer efforts to easily and efficiently analyze the behavior of their applications.

Sight Tool

Sight supports developer efforts to track information about their program behaviors that include performance, accuracy and text logs. The proposed visualization techniques in this poster are embedded in Sight to present this information in an useful way to help developer explore the behavior more efficiently.

Program Behaviors

Complex Use-cases

Track logical flow of application execution identify correlation and variation between application performance and its state.

Complex Program

Real applications have millions of lines of code and run on thousands of processors.

Taming Complexity

When debug logs grow to MBs, GBs in size it becomes infeasible to find bugs.

→ **Need hierarchical graph and multidimensional visualizations**

Program Behavior Visualization

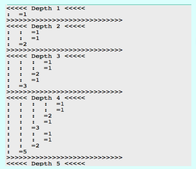
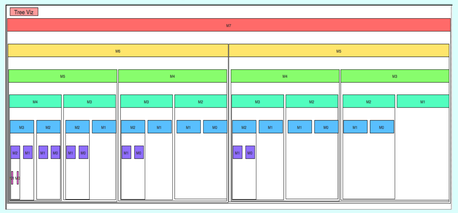
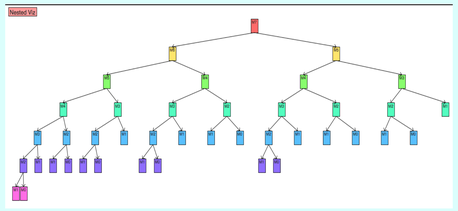


Figure 1: Raw log

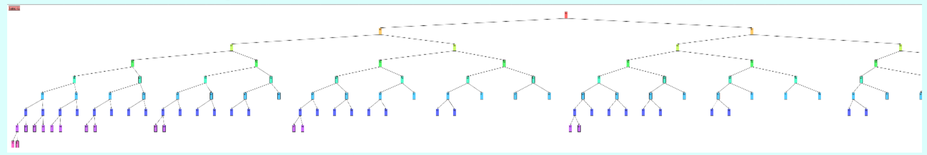
- **Problem:** The large size debug logs makes them difficult to understand. This makes it necessary to structure logs at a high level and provide developers the ability to focus on the regions that are most relevant to their tasks. → **Propose hierarchical graph with zooming, expand/collapse interactions**



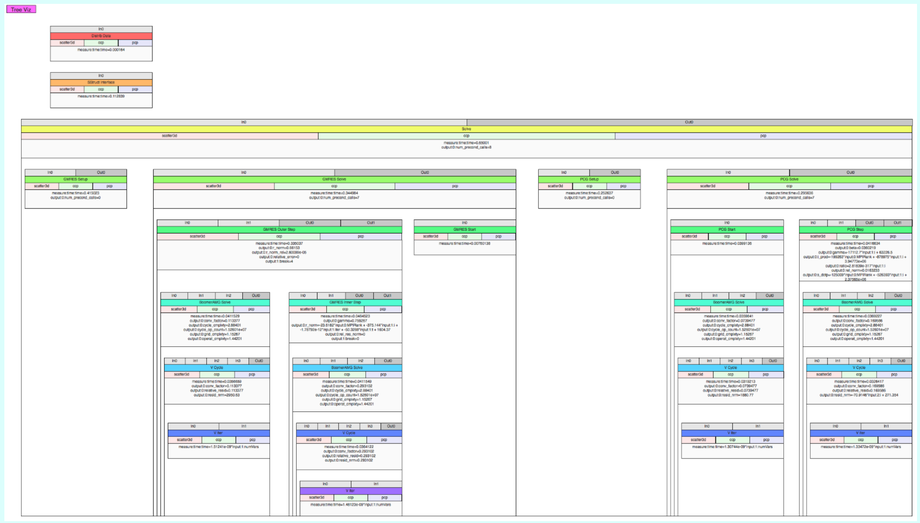
(a) Fibonacci Program – Nest View



(b) Fibonacci Program - Tree View



(c) Fibonacci Program - Tree View for 108 nodes



(d) AMG Program - Nest View

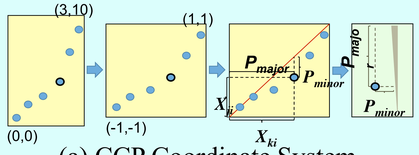
Figure 2: Flow Graph for Program Behaviors.

- **Interactive Flow Graph:** Nest/tree visual encodings & expand/collapse, zooming interactions represent repetitive structural patterns in program behaviors such as nested loops, tree recursion in program's communication graph.
- **Scalability:** This viz can be applied for very large scale program behaviors.
- **Evaluation – Case Study:** Fibonacci, AMG2013 Benchmark.

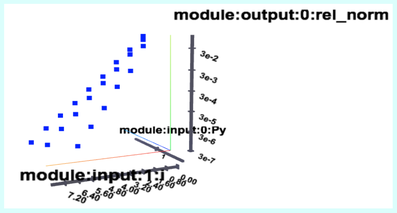
Multi-Dimensional Visualization

- **Problem:** To track the relationships between various properties of application state and performance measurements developers need effective visualization techniques.
- **Scatter Plot 3D (SCP) -** Identify relationship of three dimensions but not all dimensions' relationship.
- **Parallel Coordinates (PCPs) -** Present the trends of all dimensions but require heavy interactions.

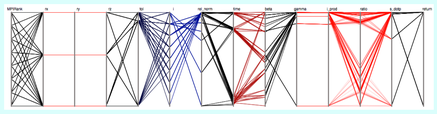
→ **Propose Correlation Coordinate Plot (CCP)/Snowflake Visualization.**



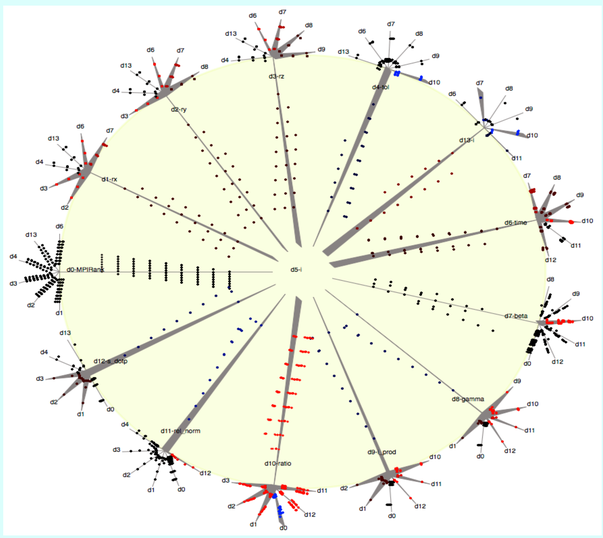
(a) CCP Coordinate System



(b) Scatter Plot 3D



(c) Transparency PCPs



(d) Snowflake Visualization

Figure 5: Multidimensional Visualizations for AMG Program

- **Snowflake Visualization -** *Design*: New Focus+Context View design with new visual encoding CCP. *Interactions*: Swapping, zooming, selection.
- **Evaluation - User Study** (25 people, 3 experiments): CCPs/Snowflake improves the identification correlation in data with higher accuracy and faster speed than SCP, PCP.

Conclusion

The Interactive Flow Graph visualizes program behaviors efficiently by optimal visual encoding, graph algorithm and interactions. This visualization can be applied for large scale program to enable developers to easily analyze complex program behaviors.

Multidimensional Visualizations help developers improve identification correlation, reduce human error, improve speed and quality of decision making for exploring program behaviors.

In our future work, we will apply our methods to analyze large-scale program behaviors.

Source Code: https://github.com/bronevet/sight/tree/hoaViz

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