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Research Interests

Static analysis techniques for parallelization (more broadly, high performance computing). Analysis of trade-offs between different metrics of performance (i.e., energy and speed). Application of machine learning techniques to compiler optimizations.

Education

Doctor of Philosophy, Computer Science — Defended Fall 2012
Colorado State University, Fort Collins, CO

Master of Science, Computer Science — December 2009
Colorado State University, Fort Collins, CO

Bachelor of Science, Computer Science — May 2007
Colorado State University, Fort Collins, CO

Dissertation Topic

MPI Code Generation in the Polyhedral Model. We proposed a method for automatic parallelization targeting distributed memory architecture in the polyhedral model. The parallelization is based on *parametric* tiling, where many of the existing techniques for polyhedral programs are not directly applicable due to non-affine nature of parametrized tiling. The core idea is in utilizing uniformization/localization techniques that are rarely used in the multi-core era for simplifying communication.

Memberships

ERCIM "Alain Bensoussan" Fellow — Mar. 2013 – Mar. 2014

Professional Experience

Post-doc, University of Rennes 1 (CAIRN team) — IRISA — Nov. 2012 – present
INRIA Post-doctoral Fellow (CAIRN team) — INRIA Rennes — Nov. 2012 – Jun. 2014
The research topic is automatic parallelization of Scilab/Matlab programs.

Research Assistant — Colorado State University — Spring 2010 – 2012
Development of the AlphaZ system as a system for prototyping analyses, transformations, and code generators in the polyhedral model. Supported under NSF grant.

Summer Internship — IBM Research T.J. Watson Lab — May-Aug. 2008
Developed method for predicting optimal parameters for tiling (loop optimization). Adaptive models based on neural networks were used to capture differences between compilers/hardwares that affect the choice of optimal parameters without spending large human effort for analytically modeling. The method developed is now part of the XL compiler.

Teaching Assistant Colorado State University 2007-2009, Spring 2011

- Foundations of Fine Grain Parallelism: Graduate level class on polyhedral model
- Parallel Processing: Graduate level class on parallel computing
- Parallel Programming: Senior level class on parallel programming (MPI and OpenMP)
- Embedded Systems: Senior level class on embedded systems, FPGAs

Projects

AlphaZ The AlphaZ system is an open-source system for polyhedral analyses, transformations, and code generators. The system models reductions (associative and commutative operator applied to a set of points) as first-class objects, enabling powerful reasoning capabilities that can lead to equivalent programs with reduced asymptotic complexity. Another strength of the system is that it completely decouples the specification of the computation and how it should be executed (i.e., schedule, memory allocation).

MPI Code Generation My dissertation work includes implementation of a code generator in the AlphaZ system that targets distributed memory architecture. Recent advances in the polyhedral literature have enabled efficient parallelization for shared memory architecture. However, with the current trends in the hardware, it is unlikely that shared memory will scale to thousands of cores. In this project, we propose a novel approach for generating code for distributed memory architecture using the Message Passing Interface. Our approach further distinguishes itself from related work by generating code based on parametric tiling, which fall outside of polyhedral model. Parametrization is the key for efficient auto-tuning and to cope with differing performance considerations based on problem sizes, and the target platform.

Verification of Parallel Programs We have developed a tool that verifies the legality of OpenMP pragmas using polyhedral machinery as a Eclipse plug-in. Recently, we have been collaborating with Dr. Vijay Saraswat, one of the core members involved in the X10 language development, to provide safety guarantee of X10 programs. Parallel constructs in X10 can express parallelism that cannot be expressed in OpenMP, or by the conventional polyhedral notion of time. This project entails extending the polyhedral notion of time such that any possible in-deterministic behavior introduced by parallel constructs can be found.

Peer Reviewed Publications

1. Gaël Deest, Tomofumi Yuki, Olivier Sentieys, and Steven Derrien "Toward Scalable Source Level Accuracy Analysis for Floating-point to Fixed-point Conversion", 33rd International Conference on Computer-Aided Design (To Appear), 2014,

2. Tomofumi Yuki "Understanding PolyBench/C 3.2 Kernels" (position paper), 4th International Workshop on Polyhedral Compilation Techniques (IMPACT'14), Vienna, Austria, January, 2014

3. Tomofumi Yuki, Antoine Morvan, and Steven Derrien "Derivation of Efficient FSM from Loop Nests" 2013 International Conference on Field-Programmable Technology, December 9-11, 2013

4. Tomofumi Yuki and Sanjay Rajopadhye "Folklore Confirmed: Compiling for Speed = Compiling for Power" 26th International Workshop on Languages and Compilers for Parallel Computing, September 25-27, 2013

5. Antoine Floc'h, Tomofumi Yuki, Ali El-Moussawi, Antoine Morvan, Kevin Martin, Maxime Naullet, Mythri Alle, Ludovic L'Hours, Nicolas Simon, Steven Derrien, François Charot, Christophe Wolinski, and Olivier Sentieys "GeCoS: A Framework for Prototyping Custom Hardware Design Flows" 13th IEEE International Working Conference on Source Code Analysis and Manipulation

6. Tomofumi Yuki, Paul Feautrier, Sanjay Rajopadhye and Vijay Saraswat "Array Dataflow Analysis for Polyhedral X10 Programs" 18th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming, February 23-27, 2013

7. Tomofumi Yuki, Sanjay Rajopadhye "Memory Allocations for Tiled Uniform Dependence Programs" 3rd International Workshop on Polyhedral Compilation Techniques, January 21, 2013

8. Tomofumi Yuki and Sanjay Rajopadhye "AlphaZ and the Polyhedral Equational Model" Second International Workshop on Domain-Specific Languages and High-Level Frameworks for High Performance Computing, November 2012

9. Tomofumi Yuki, Gautam Gupta, DaeGon Kim, Tanveer Pathan, and Sanjay Rajopadhye. "AlphaZ: A System for Design Space Exploration in the Polyhedral Model", 25th International Workshop on Languages and Compilers for Parallel Computing, September 11-13, 2012

10. Antoine Floch, Tomofumi Yuki, Celement Guy, Steven Derrien, Benoit Combemale, Sanjay Rajopadhye, and Robert France. "Model-driven engineering and optimizing compilers: a bridge too far?", International Conference on Model Driven Engineering Languages and Systems, October 16-21, 2011

11. Vamshi Basupalli, Tomofumi Yuki, Sanjay Rajopadhye, Antoine Morvan, Steven Derrien, Patrice Quinton, and David G. Wonnacott. "ompVerify: Polyhedral Analysis for the OpenMP Programmer", International Workshop on OpenMP, June 13-15, 2011

12. Tomofumi Yuki, Lakshminarayanan Renganarayanan, Sanjay Rajopadhye, Charles Anderson, Alexandre E. Eichenberger, and Kevin O'Brien. "Automatic Creation of Tile Size Selection Models", International Symposium on Code Generation and Optimization, April 24-28, 2010

Technical Reports

1. Tomofumi Yuki and Sanjay Rajopadhye. "Diminishing Returns of Frequency Scaling", Technical Report CS-13-107, August 27, 2013

2. Tomofumi Yuki and Sanjay Rajopadhye. "Parametrically Tiled Distributed Memory Parallelization of Polyhedral Programs", Technical Report CS-13-105, June 10, 2013

3. Sanjay Rajopadhye, Guillaume Iooss, Tomofumi Yuki, and Dan Connors. "The Stencil Processing Unit: GPGPU Done Right", Technical Report CS-13-103, March 1, 2013

4. Tomofumi Yuki, Tanveer Patahan, Gautam Gupta, and Sanjay Rajopadhye. "Systematic Implementation of fast-i-loop in UNAfold using AlphaZ", Technical Report CS-12-102, May 31, 2012

5. Tomofumi Yuki, Vamshi Basupalli, Gautam Gupta, Guillaume Iooss, DaeGon Kim, Tanveer Pathan, Pradeep Srinivasa, Yun Zou and Sanjay Rajopadhye. "AlphaZ: A System for Analysis, Transformation, and Code Generation in the Polyhedral Equational Model", Technical Report CS-12-101, May 31, 2012

6. Tomofumi Yuki and Sanjay Rajopadhye. "Canonic Multi-Projection: Memory Allocation for Distributed Memory Parallelization", Technical Report CS-11-106, September 20, 2011

Talks

1. Tomofumi Yuki, Antoine Morvan, and Steven Derrien. "Far Fetched Prefetching?", 6th French Compilation Days, April 2-4, 2013

2. Tomofumi Yuki, Sanjay Rajopadhye, Robert France, Antoine Floch, Clement Guy, Steven Derrien, and Benoit Combemale. "Leveraging Model-Driven Engineering Techniques in Optimizing Compiler Research", Workshop on Real-time, Embedded and Enterprise-Scale Time-Critical Systems, April 17-19, 2012