

# Riyadh Baghdadi

---

Webpage: [people.csail.mit.edu/baghdadi/](http://people.csail.mit.edu/baghdadi/)  
LinkedIn: [www.linkedin.com/in/mrbaghdadi/](http://www.linkedin.com/in/mrbaghdadi/)  
Google Scholar: [Link](#)

New York University Abu Dhabi (NYUAD)  
A2-185, Saadiyat Island, UAE  
+971565262837, [baghdadi@nyu.edu](mailto:baghdadi@nyu.edu)

---

## Research Areas

---

- Intersection of **applied machine learning** and **compilers**:
    - **Machine learning** for **compilers** (e.g., automatic code optimization, and deep learning based heuristics).
    - **Compilers** for **machine learning** (compilers for deep learning hardware accelerators and for optimizing ML).
  - **Compilers** for **high performance computing**, **tensor algebra**, **image processing**, ...
- 

## Education and Postdoctoral Training

---

- PostDoc**    **Massachusetts Institute of Technology, USA**  
Postdoctoral Associate (2015 - 2020).  
Advisor: Saman Amarasinghe.
- Ph.D.**        **Sorbonne University, France.**  
Ph.D., in Computer Science (2011 - 2015).  
Affiliated to INRIA and ENS.  
Advisor: Albert Cohen (Google Brain).
- M.S.**        **Sorbonne University, France.**  
M.S., in Computer Science (2010 - 2011).  
Advisor: Albert Cohen (Google Brain).
- Eng.**        **Ecole Superieure d'Informatique, Algeria.**  
Engineering Degree in Computer Science (2005 to 2010).
- 

## Professional Experience

---

### NYU Abu Dhabi - Assistant Professor/Maitre de Conferences (2021 - Present).

- Leading a research team working around the intersection of compilers, deep learning and high performance computing.
- Teaching CSO (Computer Systems Organization - CS-UH-2010). This course provides an introduction to systems. Topics taught include data representation (bits, bytes, strings, etc.), low level machine programming (C and assembly), memory hierarchy, virtual memory, code optimization, web services and cloud computing.

### MIT - Affiliate Researcher (2021 - Present).

- Affiliated to the COMMIT research team (Pr. Saman Amarasinghe). Participate in research projects related to compilers, deep learning and HPC.

### MIT - Postdoctoral Associate (2015 - 2020).

- Led the team that developed Tiramisu (<http://tiramisu-compiler.org/>), a polyhedral compiler for deep learning, tensor algebra and image processing. It is the first polyhedral compiler to generate code that matches or outperforms highly optimized industrial linear algebra and deep learning libraries (in particular, the most challenging single-kernels from the Intel MKL and MKL-DNN libraries). Compared to state-of-the-art DNN compilers, Tiramisu has the unique ability to parallelize multi-layer RNNs and to exploit DNN weight sparsity. It is open source and has a growing community of contributors from more than 10 industrial and academic institutions.

- Led a team that developed an accurate cost model for automatic code optimization. The cost model is built using deep learning and used to search the space of compiler optimizations and choose the best combination of optimizations. It is the first deep learning based cost model for full programs that does not require heavy feature engineering.
- Collaborated with researchers from UC Berkeley and Facebook to develop an automatic code optimization technique for the Halide compiler. This technique relies on deep learning to create a cost model.
- Member of multiple teams/projects: GraphIt (a DSL compiler for graph analytics), Seq (a python compiler for genomics' applications) and FROST (a DSL backend for FPGA).

#### **NVIDIA - Internship (4 months during 2013).**

- Participated in the development of the Nvidia NOVA DSL compiler. A fully automatic DSL for image processing targeting CUDA.

#### **Sorbonne University (Paris) - Graduate Student (2011 - 2015).**

- Led the team that designed the PENCIL language, a subset of C crafted to allow compilers to generate efficient code for hardware accelerators. This project was a part of the CARP European project and led to many collaborations with industrials and academic institutions including ARM, and Imperial College.
- Developed a technique that relaxes the tiling legality check to allow compilers to apply loop tiling even if the code has false dependences.
- Developed a technique that improves the scalability of automatic optimization in polyhedral compilers (accelerates the Pluto algorithm by 100× on average).
- Member of the team that developed the PENCIL/PPCG polyhedral compiler. Worked mainly on GPU code generation (OpenCL). PENCIL/PPCG is an automatic polyhedral compiler that was recently used to build Tensor Comprehensions, the Facebook deep learning compiler.

#### **Google - Google Summer of Code (3 months during 2010).**

- Designed and implemented a pass to import/export the polyhedral representation of programs from GCC.

## **Awards**

1. **Bronze medal** in the ACM Student Research Competition (CGO 2015).
2. **Bronze medal** in the ACM Student Research Competition (CGO 2012).
3. **Google summer of code 2010** (\$5000).
4. **Excellence award** for publishing a paper while still a sophomore student (2nd year undergraduate student).
5. **Ranked second nationwide** in the **Microsoft Imagine Cup** competition (2007 and 2008).

## **Teaching Experience**

**NYU Abu Dhabi** • **Computer Systems Organization - CS-UH-2010**. Principal instructor in a class of undergraduate computer science students. This course provides an introduction to systems. Topics taught include data representation (bits, bytes, floats, strings, etc.), low level machine programming (C and assembly), memory hierarchy, virtual memory, code optimization, web services and cloud computing. Responsibilities included designing and teaching the whole course.

**MIT** • **MIT Kaufman Teaching Certificate Program**. Trained and certified for teaching by the MIT KTCP Program.  
 • **Programming High-performance Systems**. Gave a guest lecture about the Tiramisu compiler.

#### **Sorbonne University**

- **Introduction to Programming (C Language)**. Teaching assistant in a class of 40 undergraduate computer science students.

- **Imperative Programming in Fortran.** Teaching assistant in a class of 40 undergraduate mechanical engineering students.
- **GPGPU programming (CUDA).** Teaching assistant in a class of 30 graduate computer science students.

**ESI** • **Programming High-performance Systems.** Principal instructor in a class of 60 graduate computer science students. The class included programming shared memory systems (OpenMP), programming distributed memory systems (MPI), programming GPUs (CUDA), and code optimization techniques. Responsibilities included designing and teaching the whole class.

## Papers

Published peer-reviewed papers in conference/journal papers in the venues OOPSLA, SIGGRAPH, ACM TACO, PACT, CGO, ASAP, ICCD and LCTES.

### Conference and Journal Papers

1. *“Learning to Optimize Halide with Tree Search and Random Programs”*. [PDF][WebSite]  
**SIGGRAPH 2019** (Special Interest Group on Computer Graphics and Interactive Techniques).  
Andrew A., Karima M., Luke A., Tzu-Mao L., Michael G., Riyadh Baghdadi, Steven J., Benoit S., Jonathan R., Fredo D.  
Acceptance rate: 29%.
2. *“Seq: A high-performance language for computational biology”*. [PDF][WebSite]  
**OOPSLA 2019** (Object-Oriented Programming, Systems, Languages & Applications).  
A. Shajii, I. Numanagic, Riyadh Baghdadi, B. Berger, S. Amarasingh.  
Acceptance rate: 36%.
3. *“Tiramisu: A Polyhedral Compiler for Expressing Fast and Portable Code”*. [PDF] [WebSite].  
**CGO’19** (Code Generation and Optimization).  
Riyadh Baghdadi, J. Ray, M. B. Romdhane, E. D. Sozzo, A. Akkas, Y. Zhang, P. Suriana, S. Kamil, S. Amarasinghe.  
Acceptance rate: 30%.
4. *“GraphIt - A High-Performance DSL for Graph Analytics”*. [PDF][WebSite]  
**OOPSLA’18** (Object-Oriented Programming, Systems, Languages & Applications).  
Y. Zhang, M. Yang, Riyadh Baghdadi, S. Kamil, J. Shun, S. Amarasinghe.  
Acceptance rate: 29%.
5. *“A Unified Backend for Targeting FPGAs from DSLs”*. [PDF]  
**ASAP’18** (2018 IEEE 29th International Conference on Application-specific Systems, Architectures and Processors ).  
E. Sozzo, Riyadh Baghdadi, S. Amarasinghe, and M. Santambrogio.  
Acceptance rate: 30%.
6. *“A Common Backend for Hardware Acceleration on FPGA”*. [PDF]  
**ICCD’17** (37th IEEE International Conference on Computer Design).  
E. D. Sozzo, Riyadh Baghdadi, S. Amarasinghe, M. D. Santambrogio.  
Acceptance rate: 29%.
7. *“PENCIL: a Platform-Neutral Compute Intermediate Language for Accelerator Programming”*. [PDF][WebSite]  
**PACT’15** (International Conference on Parallel Architectures and Compilation Techniques).  
Riyadh Baghdadi, U. Beaugnon, A. Cohen, T. Grosser, M. Kruse, C. Reddy, S. Verdoolaege, J. Absar, S. v. Haastregt, A. Kravets, A. Lokhmotov, A. Betts, J. Ketema, A. F.~Donaldson, R. David, E. Hajiyev.  
Acceptance rate: 21%.
8. *“VOBLA: A Vehicle for Optimized Basic Linear Algebra”*. [PDF]  
**LCTES’14** (Languages, Compilers, Tools and Theory of Embedded Systems).  
U. Beaugnon, A. Kravets, S. V. Haastregt, Riyadh Baghdadi, D. Tweed, J. Absar, A. Lokhmotov.  
Acceptance rate: 31%.
9. *“Improved Loop Tiling Based on the Removal of Spurious False Dependences”*. [PDF]  
**ACM TACO** (ACM Transactions on Architecture and Code Optimization).  
Riyadh Baghdadi, A. Cohen, S. Verdoolaege, K. Trifunovic.  
Acceptance rate: 30%.

## Workshops

1. *"SALSA: A Domain Specific Architecture for Sequence Alignment"*.  
**27<sup>th</sup> RAW** (Reconfigurable Architectures Workshop) at IPDPS 2020, May., 2020, New Orleans, Louisiana, USA.  
L. D. Tucciy, Riyadh Baghdadi, S. Amarasinghe, M. D. Santambrogio.
2. *"Tiramisu: A Polyhedral Compiler for Dense and Sparse Deep Learning"*. [PDF]  
**Systems for ML** workshop at NeurIPS 2019, Dec., 2019, Vancouver, Canada.  
Riyadh Baghdadi, K. Abdous, A. N. Debbagh, B. F. Zohra, A. Renda, J. E. Frankle, M. Carbin, S. Amarasinghe.
3. *"Scalable Polyhedral Compilation, Syntax vs. Semantics: 1-0 in the First Round"*. [PDF]  
**IMPACT** (10th International Workshop on Polyhedral Compilation Techniques). Jan., 2020. Bologna, Italy.  
Riyadh Baghdadi, A. Cohen.
4. *"Language Support For Better Polyhedral Compilation Targeting Accelerators"*.  
**GRGPL'15** (Journées du Groupement de Recherche Génie de la Programmation et du Logiciel), France.  
Riyadh Baghdadi.
5. *"PENCIL: A platform-neutral intermediate language for the parallelizing compilation of DSLs"*.  
**DSLDI'14** (Domain-Specific Language Design and Implementation), Portland, Oregon, USA.  
U. Beaugnon, Riyadh Baghdadi, J. Absar, A. Betts, A. Cohen, A. Donaldson, T. Grosser, S. V. Haastregt, Y. Hu, J. Ketema, A. Kravets, A. Lokhmotov, S. Verdoolaege.
6. *"Pencil: Towards a Platform-Neutral Compute Intermediate Language for DSLs"*.  
**WOLFHPC'12** (DSLs and High-Level Frameworks for High Performance Computing), in conjunction with OOPSLA.  
Riyadh Baghdadi, A. Cohen, S. Guelton, S. Verdoolaege, J. Inoue, T. Grosser, G. Kouveli, A. Kravets, A. Lokhmotov, C. Nugteren, F. Waters, A. F.~Donaldson. [PDF]
7. *"The Potential of Synergistic Static, Dynamic and Speculative Loop Nest Optimizations for Automatic Parallelization"*.  
**PESPMA'10** (Parallel Execution of Sequential Programs on Multi-core Architectures), in conjunction with ISCA.  
Riyadh Baghdadi, A. Cohen, C. Bastoul, L-N. Pouchet and L. Rauchwerger.

## Reports and Papers Under Review

1. *"An Expressive Polyhedral Compiler for Deep Learning"*.  
[Under Review]
2. *"Building Cost Models for Full Programs Using Deep Learning"*.  
[Under Review]
3. *"PENCIL Language Specification"*.  
Research Report RT-8706, INRIA.  
Riyadh Baghdadi, A. Cohen, S. Verdoolaege, T. Grosser, J. Absar, S. v. Haastregt, A. Kravets, A. Lokhmotov, A. F.~Donaldson.  
[PDF]

---

## Presentations, Posters and Invited Talks

---

### Tiramisu - Accelerating Deep Learning

1. Microsoft, Feb. 2020.
2. Nvidia, Dec. 2019.
3. MIT, FastCode Seminar, Oct. 2019.
4. Microsoft, Aug. 2019.
5. BigStream, Aug. 2019.
6. Cerebras, Aug. 2019.
7. SRC TECHCON, Sep. 2019 (Austin, TX, USA).
8. Apple Sep. 2018.
9. 2019 MIT Alliances annual meeting, Jun. 2019 (Cambridge, MA, USA).
10. 2018 MIT Alliances annual meeting, Jun. 2018, (Cambridge, MA, USA).

## Tiramisu - General

1. *"A Platform for Exploring Machine Learning Based AutoScheduling"*.  
Workshop on Optimization, Modeling, Analysis and Space Exploration, Feb. 2019.  
Riyadh Baghdadi.
2. *"Accelerating LQCD Calculations Using the Tiramisu Compiler"*.  
Advanced Computing Principal Investigator (PI) Meeting, July 2019, Rockville, MD.  
Riyadh Baghdadi, M Wagman, A. Pochinsky, S. Amarasinghe, W. Detmold.
3. *"The Tiramisu Polyhedral Compiler for Deep Learning and Dense Computations"*.  
MIT PL Offsite meeting, May 2019, Cambridge, MA, USA.  
Riyadh Baghdadi
4. *"Tiramisu: A High-Performance Compiler for Domain-Specific Architectures"*.  
2019 ADA Annual Symposium (Center for Application Driven Architectures), April 2019. Ann Arbor, MI, USA.  
Riyadh Baghdadi

## PENCIL - General

1. *"PENCIL: a subset of C99 for Accelerator Programming"*.  
LAMIH Seminar, University of Valenciennes, Sep 2015, Valenciennes, France.  
Riyadh Baghdadi.
2. *"PENCIL: a Platform-Neutral Compute Intermediate Language for DSL Compilers and for Accelerator Programming"*.  
MIT Seminar - Massachusetts Institute of Technology, May 2015, Cambridge, Massachusetts.  
Riyadh Baghdadi.
3. *"Extending the Scope of Polyhedral Compilation: Progress in Handling Irregular Codes and in Scalability"*.  
ACM SRC, CGO 2015.  
Riyadh Baghdadi.
4. *"Generating Highly Optimized CUDA and OpenCL from Domain Specific Languages"*.  
Google PhD Student Summit, 2014.  
Riyadh Baghdadi.
5. *"Language support for polyhedral compilation: evaluation on image processing benchmark"*.  
8'th meeting of the french compiler community, 2014.  
Riyadh Baghdadi, S. Verdoolaege, U. Beaugnon, A. Cohen, R. David and E. Hajiyev.
6. *"Putting Polyhedral Optimization Techniques to Work in Production Compilers: Progresses in Scalability and Memory Management"*.  
ACM SRC, CGO 2012.  
Riyadh Baghdadi.
7. *"A relaxed permutability criterion"*.  
Dixiemes rencontres de la communaute francaise de compilation, Sep 2015, Banyuls-sur-Mer, France  
Riyadh Baghdadi.

---

## Funding and Grant Awards

---

Participated in writing multiple grant proposals (without PI status), the following grant proposals were accepted.

- Program name: DARPA D3M (Data-Driven Discovery of Models). Accepted proposal: Human Data Interaction (DARPA-16-43-D3M-FP-041).
- Program name: DARPA PAPP (Performant Automation of Parallel Program Assembly). Accepted proposal: High-Performance Productivity and Portability with Domain Specific Languages (DARPA-PA-19-04-02-FP-019).
- Program name: DOE SCIDAC (Scientific Discovery Through Advanced Computing). Accepted proposal: Computing the Properties of Matter with Leadership Computing Resources (DE-SC0018121).

- Program name: MIT Alliances FinTech funding (FinTech@MIT). Accepted proposal: A DSL for Real-time, Low-latency Financial Computations.
- Program name: Advanced Simulation and Computing Predictive Science Academic Alliance Program (PSAAP III). Accepted proposal: CESMIX - Center for the Exascale Simulation of Material Interfaces in Extreme Environments.

## Service

### Reviews & Program Committee Membership

1. **Journal reviews:** ACM TACO (Transactions on Architecture and Code Optimization), ACM TOPC (Transactions on Parallel Computing), Elsevier PARCO (Parallel Computing), Elsevier JPDC (Journal of Parallel and Distributed Computing), Springer IJPP (International Journal of Parallel Programming), IEEE Access Journal.
2. **Conference reviews:** PACT'19.
3. **Workshop reviews:** RWDSL'18 (Workshop on Real World Domain Specific Languages), GPGPU'10 (Workshop on General-Purpose GPU).

### Workshop Organization

1. Organizer of the Workshop on Automatic Code Optimization (Feb., 2020, Cambridge, MA, USA).

## Student Mentoring

- Visiting PhD students (interns).
  - Lorenzo Di Tucci (visiting from Politecnico di Milano, 2018-2019). Paper under review.
  - Emanuele Del Sozzo (visiting from Politecnico di Milano, 2017-2018). Two papers published.
- Master students (MIT, USA)
  - Abdurahmane Akkas (2018-2019). *“Efficient Memory and GPU Operations for Tiramisu Compiler”*. [PDF]
  - Malek Ben Romdhane (2017-2018). *“Extending the Capabilities of Tiramisu”*. [PDF]
- Master students (ESI, Algeria)
  - M. Merouani, M. H. Leghettas (2019-2020). *“Building a Deep Learning Based Cost Model for Code Optimization in Tiramisu”*. (ongoing).
  - K. Abdous (2019-2020). *“Automatic Code Optimization Algorithm for Tiramisu”*. (ongoing).
  - H. Benmeziane (2019-2020). *“Integrating Tiramisu in the Pytorch DNN Framework”*. (ongoing).
  - A. N. Debbagh (2019-2020). *“Optimizing Sparse DNNs using Tiramisu”*. (ongoing).
  - T. Ihadadene (2018-2019). *“Generating Communication Code for Distributed Programs”*. [PDF]
  - M. I. Isra, M. Henni (2018-2019). *“A Deep Learning Approach for Automatic Code Optimization”*. [PDF]
  - G. Amal (2018-2019). *“Generation automatique de communication CPU/GPU pour le backend GPU de Tiramisu”*. [PDF]
  - G. Taklit, A. Balamane (2018-2019). *“Proposition d’un modèle pour l’optimisation automatique de boucles”*. [PDF]
  - H. Radja (2018-2019). *“Implementing and Optimizing Neural Networks using Tiramisu”*. [PDF]
  - I. Manseri (2017-2018). *“Design and implementation of an optimizer for programs written in Halide”*.

## References

### Saman Amarasinghe

MIT, EECS  
saman@csail.mit.edu  
+1 781-888-0816

### Albert Cohen

Google AI  
albertcohen@google.com  
+33 66 88 62 206

### William Detmold

MIT, CTP  
wdetmold@mit.edu  
+1 617-324-6181

### J. (Ram) Ramanujam

EECS, LSU  
jxr@ece.lsu.edu  
+1 225-200-6386