Aman Nougrahiya

Doctoral Research Scholar
PACE Lab, SSB 216, Department of CS&E, IIT Madras (India)
Email: amannoug@cse.iitm.ac.in ✉
LinkedIn: amannoug⍐

Contact: +91-9962609717
Website: www.cse.iitm.ac.in/~amannoug⍐
GitHub: amannougrahiya⍐
Google Scholar: Aman Nougrahiya⍐

Summary

Compiler researcher (PhD thesis submitted) with 10+ years of academic experience in **compiler construction**, **static analysis**, **incremental compilation** and **program optimizations**. Published two first-author journal papers – in **ACM TOPLAS** and PACMPL **(ACM OOPSLA)**. Sole developer of the **IMOP** compiler framework (spans 170kLOC; used in 9 research papers). Holds a patent granted in India, with international filings in US and China. Delivered talks in esteemed global universities, such as *Harvard University*, *Brown University*, and *UT Austin*, among others.

Education

PhD + MS (Dual Degree) – Computer Science, IIT Madras, India *Jul 2012 - Present*
Thesis Title: Design and Implementation of Efficient Self-Stabilizing Compilers (CGPA: 9.6)
Advisor: Prof. V. Krishna Nandivada
Thesis submitted: Dec 2024; *Expected graduation:* **Feb-Mar 2025**

Bachelor of Engineering – Information Technology, OIST Bhopal, India *Aug 2007 - May 2011*
With Honors (78.2%)

Publications

[1] *IncIDFA: an Efficient and Generic Algorithm for Incremental Iterative Dataflow Analysis.* *Apr 2025*
  Nougrahiya, Aman, and Nandivada, V. Krishna.
  To appear in the Proceedings of ACM on Programming Languages (PACMPL, ACM OOPSLA 2025).

[2] *Homeostasis: Design and Implementation of a Self-Stabilizing Compiler.* *Jun 2024*
  Nougrahiya, Aman, and Nandivada, V. Krishna.
  ACM Transactions on Programming Languages and Systems (ACM TOPLAS). Vol. 46, Issue 2, Article 6, Pages 1-58. Invited oral presentation given at ACM OOPSLA 2024 (Pasadena, USA). https://doi.org/10.1145/3649308⍐

Patents

[1] *System and Method for Performing Self-Stabilizing Compilation.*
  Nandivada, V. Krishna, and **Nougrahiya, Aman**. IIT Madras.
  - U.S. Patent⍐: Published. Application No. US20240020101A1 *Jan 2024*
  - China Patent⍐: Published. Application No. CN116583822A *Aug 2023*
  - Indian Patent⍐: Granted. Patent No. 383458 *Dec 2020*

Selected Research Projects

Key open-source⍐ projects that I independently designed and developed with my advisor, V. Krishna Nandivada:

The IMOP Compiler Framework

- **IMOP**⍐ is an open-source compiler framework for writing program analysis, profiling, and source-to-source optimization passes for **OpenMP C** programs.
- Developed exclusively as part of my doctoral research work, IMOP comprises over **170k** lines of code in Java.
- IMOP has been utilized as the implementation platform for **9 research papers**⍐ published at esteemed venues, including TOPLAS, OOPSLA (PACMPL), TACO, PACT, and others.
- Co-organized and presented **five half-day tutorials** (video link⍐) on IMOP at reputed venues – **CGO 2020**, **CGO 2021**, **PLDI 2021**, **CGO 2022**, and **CGO 2023**. (Next tutorial: **CGO 2025**⍐.)

Self-Stabilizing Compilation

- Proposed **Homeostasis**, a novel compiler design to enable *self-stabilization* in object-oriented compilers.
- Tackles a long-standing challenge: When a program undergoes multiple optimizations during its compilation, the results of various program analyses may need to be *stabilized*, that is, made consistent with the modified program. Manual stabilization is cumbersome and error-prone.

- *Homeostasis* performs stabilization of all analysis-results **automatically** and **efficiently**, without requiring any additional effort from the compiler pass writers.
- Published in **ACM TOPLAS**⬈; patent granted in India⬈, with international filings in US⬈ and China⬈.

Incremental Iterative Dataflow Analysis
- Proposed ***IncIDFA***, a novel algorithm that delivers a precise and efficient incremental version of any monotone iterative dataflow analysis (IDFA), supporting **arbitrary lattices** and dataflow functions.
- Ensures **no loss of precision** in incremental updates of dataflow solutions compared to full recomputation.
- Enables **fully automated incrementalization** of new dataflow problems, supporting **arbitrary program changes**.
- Achieved up to $11\times$ **speedup** in IDFA stabilization time during evaluations on real-world benchmark programs.
- Accepted for publication in **PACMPL (ACM OOPSLA 2025)**.

Automating Static Analyses with SAT/SMT Solvers
- Integrated Microsoft's **Z3 SMT solver** into **IMOP**, enabling automation of various static analyses.
- Addressing a critical challenge: While SMT solvers enable complex analyses (e.g., field-sensitive inter-thread dependence analysis) by expressing them as systems of constraints, manually generating these constraints is tedious, error-prone, and difficult for compiler writers.
- Automates both **the generation of constraint systems** and **the invocation of the Z3 solver**, providing precise analysis results from a seed constraint.

Incremental Concurrency Analysis
- Proposed ***IncEPA***, an efficient *incremental* and *context-sensitive* phase analysis for parallel programs.
- Phase analysis infers execution ordering relations among statement groups in a parallel program.
- *IncEPA* addresses the high cost of full recomputation of analysis results in response to program optimizations.
- Supports programming models that utilize textually unaligned and unnamed global barriers, such as OpenMP.
- Achieved up to $191\times$ **speedup** over state-of-the-art phase analysis on real-world benchmark programs.

Synchronization Optimizations
- Proposed novel compiler optimizations to reduce the total number of runtime barriers in OpenMP C programs.
- Utilized standard transformations, including **code motion**, **loop unrolling**, and **memory renaming**, while ensuring correctness under the weak memory model of OpenMP.
- Achieved up to $3\times$ **speedup** in execution time for stencil computations, such as the heated-plate simulation.

Teaching and Work Experience

Project Associate, IC&SR, IIT Madras
Projects' Coordinator: Prof. V. Krishna Nandivada
- Project Title: *1156:KAS: Keeping Analysis Stable*   *Jan 2024 - Present*
  Funded by IBM Canada Limited
- Project Title: *Efficient Analysis and Optimizations for Parallel Applications*   *Jul 2023 - Dec 2023*
  Funded by Science and Engineering Research Board (SERB), Govt. of India
- Project Title: *Programming Model/Language and Compiler for Emerging HPC Systems*   *Apr 2022 - Jun 2023*
  Funded by Ministry of Electronics and Information Technology (MEIT), Govt. of India
- Project Title: *Optimizing HPC Applications*   *Jun 2021 - Oct 2022,*
  Funded by Science and Engineering Research Board (SERB), Govt. of India   *Jun 2019 - Nov 2020*

Teaching Assistant, Dept. of CSE, IIT Madras
- Compiler Design (CS3300)   *Jul - Nov 2017, Jul - Nov 2016*
  Received the *Star TA Award* (2017), and the *Outstanding TA award* (2016).
- Modern Compilers – Theory and Practice (CS6013)   *Jan - May 2017, Jul - Nov 2013*
- Program Analysis (CS6843)   *Jan - May 2016*
- Computational Engineering (CS1100)   *Jul - Nov 2015, Jan - May 2013*
  Received the *Outstanding TA award* (2015).
- Principles of Programming Languages (CS6848)   *Jan - May 2015, Jan - May 2014*

Research Intern, Microsoft Research India   *Sep 2014 - Dec 2014*
  Project Title: *Broom: Region-Based Memory Management*   Bengaluru, India
  Mentor: Dr. Ganesan Ramalingam

Assistant Teacher, APT *(a Red Hat Certified Training Partner)*   *Aug 2011 - Mar 2012*
  Taught a batch of 15-20 students for RHCSA and RHCE certifications   Bhopal, India

Invited Talks

I have given invited talks on ***Homeostasis***: *Design and Implementation of a Self-Stabilizing Compiler*, at the following US universities:

- **Northeastern University**, Boston, USA, hosted by Prof. Arjun Guha   *Nov 2024*
- **Tufts University**, Boston, USA, hosted by Prof. Jeff Foster   *Nov 2024*
- **Brown University**, Providence, USA, hosted by Prof. Shriram Krishnamurthi   *Nov 2024*
- **Harvard University**, Boston, USA, hosted by Prof. Stephen Chong   *Oct 2024*
- **Texas State University**, San Marcos, USA, hosted by Prof. Martin Burtscher   *Oct 2024*
- **UT Austin**, Texas, USA, hosted by Prof. Keshav Pingali   *Oct 2024*

On the topic ***IMOP***: *a Self-Stabilizing Source-to-Source Compiler Framework for OpenMP C*, I have given following invited talks, tutorials, and lectures:

- Half-day tutorials at the following editions of **IEEE/ACM CGO**:
  - *(Scheduled)* **CGO 2025 Tutorials**, Las Vegas, USA   *Mar 2025*
  - **CGO 2023** Tutorials, Montreal, Canada   *Feb 2023*
  - **CGO 2022** Tutorials, Virtual   *Apr 2022*
  - **CGO 2021** Tutorials, Virtual   *Feb 2021*
  - **CGO 2020** Tutorials, San Diego, USA   *Feb 2020*
- Invited talk at **Stony Brook University**, New York, USA, hosted by Prof. Barbara Chapman   *Mar 2023*
- Half-day tutorial at **ACM PLDI 2021**, Virtual   *Jun 2021*
- Invited talk at SERI 2019, IISc Bangalore, India, sponsored by India Chapter of **ACM SIGSOFT** *July 2019*
- Invited lecture in *CS6843: Program Analysis*, by Prof. Rupesh Nasre, Dept. of CSE, IIT Madras, India *Mar 2019*

Services

- Invited as Artifact Evaluation PC member for PLDI 2025   *Mar 2025*
- Student volunteer at ACM SPLASH (OOPSLA) 2024, Pasadena, USA   *Oct 2024*
- Artifact Evaluation PC member for PPoPP 2019   *Dec 2019*
- Invited lecture on the topic *Life Lessons from Around: Approach to Adversity*   *Mar 2019*
  in the course *GN1101: Life Skills*, Dept. of Management Studies, IIT Madras
- Artifact Evaluation PC member for PPoPP 2018   *Jan 2018*
- Student volunteer at ICSE 2014, Hyderabad, India   *Jun 2014*

Technical Skills and Certifications

- *Compiler Frameworks/Tools known:* IMOP, LLVM, Microsoft's Roslyn Compiler, Soot, ROSE, JavaCC/JTB, and Microsoft's Z3 SMT Solver
- *Languages/APIs known:* Java, OpenMP, GCC C, GCC C++, Cilk, CUDA, Microsoft Visual C#, and POSIX Threads
- *Others:* Latex, Git, Docker, Bash, Awk, Vim, Gnuplot, Inkscape, DOT (a graph description language)
- *Certifications:*
  - Red Hat Certified Engineer (RHCE), for Red Hat Enterprise Linux 6
  - Red Hat Certified System Administrator (RHCSA), for Red Hat Enterprise Linux 6
  - Oracle Certified Professional↗, Java SE 6 Programmer (OCP Java SE 6)

Awards and Honours

- Received travel grants for attending ACM OOPSLA 2024, to give oral presentation on the TOPLAS paper:
  - ACM SIGPLAN PAC Travel Grant
  - ACM-IARCS Students Travel Grant
- As a teaching assistant at IIT Madras, I was granted the following awards:
  - *Star TA* award for Compiler Design (ODD 2017)
  - *Outstanding Teaching Assistant* award for Compiler Design (ODD 2016)
  - *Outstanding Teaching Assistant* award for Computational Engineering (EVEN 2015)
- GATE (Graduate Aptitude Test in Engineering) 2011 score: 99.06 percentile