Hari Govind V K

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Research

Software Model Checking

Z3, SMT, Constraint Solving, Constrained Horn Clauses

- My primary research interest is in enabling scalable and fully automatic formal verification. So far, I have been focusing on *model checking* using Constrained Horn Clauses (CHC).
- Many of my research projects have been implemented on top of Spacer : a model checking engine used to discharge software verification and theorem-proving queries.
- Spacer is part of Z3: an open source automated theorem prover framework in C++. My fork

Equality and Uninterpreted Functions *July 21 - Present*

- CHC solvers rely on SMT solvers to interpret all basic operations like addition and multiplication. However, expensive and unnecessary SMT queries slow down CHC solvers.
- Working on a CHC solver that uses Equality and Uninterpreted Functions (EUF) to abstract all theory operations.

Coherent Uninterpreted Programs *March 21 - May 21*

- Uninterpreted programs (UP) are interesting from a theoretical point of view because they are simple yet their verification is undecidable. Recently, Coherent UP have been identified as a subclass of UP whose verification is decidable.
- We give a logical characterization for Coherent UP and show that all Coherent programs are bisimilar to finite state systems
- Publication: **Vediramana Krishnan H.G.**, Shoham S., Gurfinkel A. "Logical Characterization of Coherent Uninterpreted Programs". In: Formal Methods in Computer Aided Design (2021).

Recursive Data Types and Recursive Functions *September 20 - July 21*

- Recursive data types (list, trees) appear frequently in programs. They are often coupled with recursive functions (list length, tree height). The undecidability of reasoning about recursive functions makes automatic verification very challenging for programs that manipulate recursive data types.
- Developed a new procedure that both, abstracts recursive functions and translates them to CHCs, in order to tackle undecidability.
- Publication: **Vediramana Krishnan H.G.**, Shoham S., Gurfinkel A. "Solving Constrained Horn Clauses Modulo Algebraic Data Types and Recursive Functions". In: Principles of Programming Languages (2022).

Global Guidance *February 19 - January 20*

- A constant source of frustration in using Spacer is its instability: apparently trivial changes to the input can have adverse effect on Spacer's performance. Part of the reason is that Spacer is very tightly coupled to the underlying SMT solver.
- Introduced a new technique (Global guidance) to course correct Spacer if it starts to diverge because the underlying SMT solver returned suboptimal proofs.
- Publication: **Vediramana Krishnan H.G.**, Chen Y., Shoham S., Gurfinkel A. "Global Guidance for Local Generalization in Model Checking". In: Computer Aided Verification (2020).
- Extended the technique to word level model checking
- Publication: **Vediramana Krishnan H.G.**, Fedyukovich G., Gurfinkel A. "Word Level Property Directed Reachability". In: International Conference in Computer Aided Design (2020).

Hardware Model Checking

C++, Python, bash *May 18 - February 19*

- Worked on Avy: an open source model checking tool for verifying functional correctness of digital circuits.
- Designed and implemented a new algorithm that uses the principle of k-induction to guide generalizations during search.
- Made an exponential speed up on a class of benchmark instances.
- Publications:
  Vediramana Krishnan H.G., Vizel Y., Ganesh V., Gurfinkel A. "Interpolating Strong Induction". In: Computer Aided Verification (2019).
  Vediramana Krishnan H.G.. "Strong Induction in Hardware Model Checking". Master's thesis.

SAT Solvers

C++, bash *February 2016 - April 2017*

- Implemented 7 different branching heuristics inside the Minisat Boolean SATisfiability Solver.
- Conducted an empirical study of these branching heuristics.
- Publication: Liang J.H., **Vediramana Krishnan H.G.**, Poupart P., Czarnecki K., Ganesh V. "An Empirical Study of Branching Heuristics Through the Lens of Global Learning Rate". In: Theory and Applications of Satisfiability Testing (2017).
- Runner up for the best student paper award.

Education

PhD in Electrical And Computer Engineering

Ontario, Canada

University Of Waterloo

September 2019 - Present

- Supervisor: Prof. Arie Gurfinkel.
- Relevant courses: Programming Languages Foundations in Agda, Introduction to Symbolic Computation

MASc in Electrical And Computer Engineering

Ontario, Canada

University Of Waterloo

September 2017 - August 2019

- Supervisors: Prof. Arie Gurfinkel and Prof. Vijay Ganesh.
- Relevant courses: Automated Program Verification, Computer-aided Reasoning, Convex Optimization.
- GPA: 91%.

B.Tech in Electronics and Communication Engineering

Thiruvananthapuram, India

College Of Engineering Thiruvananthapuram

June 2012 - July 2016

- GPA: 84%.

Awards

2021-2022 Microsoft Research PhD Fellow

Virtual

https://www.microsoft.com/en-us/research/academic-program/phd-fellowship/!people

2021

- One of 45 students from all over the world to receive this award.

Winner of CHC Comp

Virtual

https://chc-comp.github.io/

2020 and 2021

- CHC Comp is an annual competition to compare state-of-the-art CHC solvers.
- Our tool, Spacer, won all tracks in the 2021 CHC Competition and all but one track in the 2020 competition

Faculty of Engineers Award (FOE)

Waterloo, Canada

Presented by ECE Department, University of Waterloo

Winter 2020

- Merit driven scholarship based on comparing accomplishments of peer researchers in the department.
- One among 24 students to receive this award.

Professional Experience

Research Intern at MathWorks

Boston, USA

OCaml

May 22 - Aug. 22 and July 21 - Aug. 2021

- Worked on verifying Simulink models using Simulink Design Verifier (sldv)
- Encoded Simulink models as Constrained Horn Clauses
- Tested efficiency of CHC solver Spacer as a backend for sldv

Teaching Assistant

Waterloo, Canada

Jan. 2018 - Present

- Handled 6 undergraduate courses and 2 graduate courses
- Gave tutorials for a data structures and algorithms course.
- Handled theory and lab sections of a compilers course.
- Responsible for setting up and grading assignments and exams.

Software Engineer at Zoho Corporation

Thenkasi, India

Java, server APIs

Aug. 2016 - June 2017

- Implemented webhooks for Zoho Desk using Apache Kafka for easy integration with other services. Webhooks are asynchronous means of keeping client updated with the server's state without the client itself having to make costly network calls.
- Designed and implemented RESTfull APIs for Zoho Desk to enable loose coupling between the server and client.

Service

Proceedings chair for CAV'22, Organizer for CHC-COMP'22 and 23, Artifact Evaluation Committee member TACAS'23 and VMCAI'21