

# Curriculum Vitae

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**Name:** Leonardo de Moura

**Address:** 18530 NE 53rd CT, Redmond, WA 98052, USA

**Phone:** (425) 647-1990

**Email:** leodemoura0@gmail.com

**Homepage:** <http://leodemoura.github.io>

**Github:** <https://github.com/leodemoura>

**Nationality:** American and Brazilian

## Experience and Job History

01/2013– Senior Principal Researcher at Microsoft, Redmond, WA, USA  
present

01/2010– Principal Researcher at Microsoft, Redmond, WA, USA  
01/2013

08/2006– Senior Researcher at Microsoft, Redmond, WA, USA  
01/2010

02/2001– Computer Scientist at SRI International, Menlo Park, CA, USA  
08/2006

04/2000– Computer Engineer at Advus, São Paulo, Brazil  
12/2000

08/1994– Research Assistant at the Software Engineering Laboratory  
04/2000 of PUC-Rio

06/1998– Visiting Researcher at Semantic Designs, Austin, TX, USA  
12/1998

## Projects

I am the main architect and leader of the following projects.

- *The Lean Proof Assistant and Programming Language*, <http://leanprover.github.io>. Lean is implemented in Lean itself and is fully extensible: users can modify and extend the parser, elaborator, tactics, decision procedures, pretty printer, and code generator. Lean is also an efficient functional programming language based on a novel programming paradigm

called functional but in-place. The project has been featured in many popular science magazines, including **Nature**<sup>1 2</sup>, **Wired**<sup>3</sup>, and **Big-Think**<sup>4</sup>. Many additional links to articles and interviews are available at <https://leanprover.github.io/links/>.

- *Z3* is an efficient satisfiability modulo theories (SMT) solver, <http://github.com/z3prover/z3>. *Z3* is used in automated testing, software and hardware verification, optimization, and constraint solving applications. The project has received numerous awards including the *Programming Languages Software Award* from ACM SIGPLAN. *Z3* is widely used in industry (e.g., Microsoft, AWS, Apple, Meta, Google, to cite a few).
- *SAL* stands for Symbolic Analysis Laboratory (<https://sal.csl.sri.com/>). It is a framework for combining different tools for model checking, theorem proving, and abstraction toward the calculation of properties (symbolic analysis) of transition systems. A key part of the *SAL* framework is an intermediate language for describing transition systems, and model checking tools.

## Research Interests

Theorem Proving, Model Checkers, Software/Hardware Verification, Decision Procedures, Programming Languages, Static Analysis.

## Awards

- 2021– Distinguished paper award at PLDI  
“Perceus: Garbage Free Reference Counting with Reuse”.
- 2021– CAV Award  
for pioneering contributions to the foundations of the theory and practice of satisfiability modulo theories (SMT).
- 2019– Herbrand Award  
for numerous and important contributions to SMT solving, including its theory, implementation, and application to a wide range of academic and industrial needs.
- 2018– ETAPS 2018 Test of Time Award  
for the paper *Z3: An Efficient SMT Solver*

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<sup>1</sup><https://www.nature.com/articles/d41586-023-00487-2>

<sup>2</sup><https://www.nature.com/articles/d41586-021-01627-2>

<sup>3</sup><https://www.wired.com/story/the-effort-to-build-the-mathematical-library-of-the-future/>

<sup>4</sup><https://bigthink.com/the-future/artificial-intelligence-replace-mathematicians/>

- 2017– Skolem Award  
for the paper “Efficient E-Matching for SMT Solvers”.  
The Skolem award is given to the papers that have passed the test of time  
by being a most influential in the field of automated deduction.
- 2015– Programming Languages Software Award for Z3 from ACM SIGPLAN.
- 2014– TACAS Conference Award.  
Most influential tool paper in the first 20 years of TACAS.
- 2010– Haifa Verification Conference Award.  
The HVC award is given to the most influential work in the last five  
years in the scope of software and hardware verification and testing.
- 2007– Microsoft Gold Star (for the Z3 theorem prover)  
Microsoft
- 2005– SRI Focus Award (Outstanding Employee)  
SRI International
- 2000– Second Prize in the ACM’2000 Student Research Contest  
Association of Computing Machinery (ACM)

## Education

- 04/2000 Ph.D. in Computer Science,  
Thesis topic: “Automating the Generation of Program Analysis  
and Verification Tools”  
Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
- 03/1996 M.Sc. in Computer Science,  
Thesis topic: “Visual Development Environments”  
Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil
- 01/1994 Computer Engineer,  
Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil

## Publications

Google Scholar: <https://scholar.google.com/citations?user=CwazDKgAAAAJ&hl=en>.

1. S. Ullrich and L. de Moura, ‘do’ unchained: *Embracing local imperativity in a purely functional language*, Proc. ACM Program. Lang., ICFP, 2022.
2. L. de Moura and S. Ullrich, *The Lean 4 theorem prover and programming language*, 28th International Conference on Automated Deduction, 2021.

3. A. Reinking, N. Xie, L. de Moura, and D. Leijen, *Perceus: Garbage free reference counting with reuse*, In Proceedings of the 42nd ACM SIGPLAN International Conference on Programming Language Design and Implementation, PLDI, 2021. (*distinguished paper award*).
4. S. Ullrich and L. de Moura, *Beyond notations: Hygienic macro expansion for theorem proving languages*, 10th International Joint Conference in Automated Reasoning (IJCAR), 2020.
5. S. Ullrich and L. de Moura, *Counting immutable beans: Reference counting optimized for purely functional programming*, 31st Symposium on Implementation and Application of Functional Languages (IFP), 2019.
6. D. Selsam, M. Lamm, B. Bünz, P. Liang, L. de Moura and D. Dill, *Learning a SAT Solver from Single-Bit Supervision*, International Conference on Learning Representations (ICLR), 2019.
7. G. Ebner, S. Ullrich, J. Roesch, J. Avigad and L. de Moura, *A Metaprogramming Framework for Formal Verification*, Proc. ACM Program. Lang., ICFP, August 2017.
8. D. Selsam and L. de Moura, *Congruence Closure in Intensional Type Theory*, 8th International Joint Conference in Automated Reasoning (IJCAR), 2016.
9. R. Lewis and L. de Moura, *Automation and Computation in the Lean Theorem Prover*, International Conference on Artificial Intelligence and Theorem Proving (AITP), 2016
10. J. Avigad, L. de Moura and S. Kong. *Theorem Proving in Lean*, 2015.
11. L. de Moura, S. Kong, J. Avigad, F. van Doorn and J. von Raumer, *The Lean Theorem Prover*, 25th International Conference on Automated Deduction, 2015.
12. C. Barrett, L. de Moura and P. Fontaine, *Proofs in Satisfiability Modulo Theories*, Mathematical Logic and Foundations. College Publications, London, UK, 2015.
13. A. Reynolds, C. Tinelli and L. de Moura, *Finding Conflicting Instances of Quantified Formulas in SMT*, 14th International Conference on Formal Methods in Computer-Aided Design, 2014.
14. D. Jovanović, C. Barrett, and L. de Moura, *The design and implementation of the model constructing satisfiability calculus*, 13th International Conference on Formal Methods in Computer-Aided Design, 2013.
15. L. de Moura and G. O. Passmore, *Computation in real closed infinitesimal and transcendental extensions of the rationals*, 24th International Conference on Automated Deduction, 2013.

16. L. de Moura and G. O. Passmore, *The Strategy Challenge in SMT Solving*, Automated Reasoning and Mathematics: Essays in Memory of William W. McCune, LNAI 7788, 2013.
17. L. de Moura, D. Jovanović, *A Model-Constructing Satisfiability Calculus*, 14th International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI) 2013.
18. D. Jovanović and L. de Moura, *Cutting to the chase solving linear integer arithmetic*, Journal of Automated Reasoning, 2013 (*submitted*).
19. G. Passmore, L. C. Paulson, L. de Moura, *Real algebraic strategies for MetiTarski proofs*, 11th International Conference, AISC 2012, 19th Symposium, Calculemus 2012.
20. D. Jovanović, L. de Moura, *Solving nonlinear arithmetic*, 6th International Joint Conference in Automated Reasoning (IJCAR) 2012.
21. D. Jovanović, L. de Moura, *Solving nonlinear arithmetic*, Technical Report MSR-TR-2012-20, Microsoft Research, 2012.
22. C. Barrett, M. Deters, L. de Moura, A. Oliveras, and A. Stump, *6 Years of SMT-COMP*, Journal of Automated Reasoning, 2012.
23. N. Bjorner, and L. de Moura, *Tractability and Modern Satisfiability Modulo Theories Solvers*, Handbook of Tractability, Cambridge University Press, 2012.
24. K. Hoder, N. Bjorner, and L. de Moura, *muZ - an efficient engine for fixed points with constraints*, Computer Aided Verification (CAV) 2011.
25. L. de Moura and N. Bjorner, *Satisfiability modulo theories: introduction and applications*, Communications of the ACM, (CACM) 2011.
26. D. Jovanović and L. de Moura, *Cutting to the chase solving linear integer arithmetic*, 23rd International Conference on Automated Deduction (CADE), 2011.
27. M. P. Bonacina, C. Lynch, and L. de Moura, *On deciding satisfiability by theorem proving with speculative inferences*, Journal of Automated Reasoning, 2011.
28. M. Veanes, N. Bjorner and L. de Moura, *Symbolic Automata Constraint Solving*, International Conference on Logic programming and automated reasoning (LPAR), 2010.
29. C. Wintersteiger, Y. Hamadi and L. de Moura, *Efficiently Solving Quantified Bit-Vector Formula*, International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2010.

30. L. de Moura and N. Bjorner, *Bugs, Moles and Skeletons: Symbolic Reasoning for Software Development*, International Joint Conference on Automated Reasoning (IJCAR), 2010.
31. N. Bjorner and L. de Moura, *TAPAS Theory Combinations and Practical Applications*, invited paper at FORMATS 2009.
32. L. de Moura and N. Bjorner, *Generalized and Efficient Array Decision Procedures*, International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2009.
33. L. de Moura and N. Bjorner, *Satisfiability Modulo Theories: An Appetizer*, invited paper to SBMF 2009.
34. G. O. Passmore and L. de Moura, *Superfluous S-polynomials in Strategy-Independent Grobner Bases*, 11th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing (SYNASC), 2009.
35. L. de Moura and G. O. Passmore, *On Locally Minimal Nullstellensatz Proofs*, International Workshop on Satisfiability Modulo Theories (SMT), 2009.
36. G. O. Passmore and L. de Moura, *Universality of Polynomial Positivity and a Variant of Hilbert's 17th Problem*, ADDCT'09.
37. L. de Moura and N. Bjorner, *Z3<sup>10</sup>: Applications, Enablers, Challenges and Directions*, invited paper to CFV 2009.
38. M. P. Bonacina, C. Lynch and L. de Moura, *On deciding satisfiability by DPPL( $\Gamma+T$ ) and unsound theorem proving*, 22nd International Conference on Automated Deduction (CADE-22), 2009.
39. Y. Ge and L. de Moura, *Complete instantiation for quantified SMT formulas*, International Conference on Computer Aided Verification (CAV 2009).
40. C. Wintersteiger, Y. Hamadi and L. de Moura, *A Concurrent Portfolio Approach to SMT Solving*, International Conference on Computer Aided Verification (CAV 2009).
41. R. Piskac, L. de Moura and N. Bjorner, *Deciding Effectively Propositional Logic with Equality* Technical Report: MSR-TR-2008-181.
42. N. Bjorner, B. Dutertre and L. de Moura *Accelerating Lemma Learning using Joins - DPPL(Join)*, International Conference on Logic programming and automated reasoning (LPAR), 2008.
43. L. de Moura and N. Bjorner, *Proofs and Refutations, and Z3*, IWIL 2008.
44. N. Bjorner, L. de Moura and N. Tillmann, *Satisfiability Modulo Bit-precise Theories for Program Exploration*, Invited workshop paper, CFV 2008.

45. L. de Moura and N. Bjorner, *Deciding Effectively Propositional Logic using DPLL and substitution sets*, International Joint Conference on Automated Reasoning (IJCAR), 2008.
46. L. de Moura, N. Bjorner, *Engineering DPLL(T) + Saturation*, International Joint Conference on Automated Reasoning (IJCAR), Sydney, Australia, 2008.
47. L. de Moura and N. Bjorner, *Z3: An Efficient SMT Solver*, International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2008.
48. L. de Moura and N. Bjorner, *Relevancy Propagation*, MSR Technical Note, 2007.
49. L. de Moura and N. Bjorner, *Efficient E-matching for SMT solvers*, International Conference on Automated Deduction (CADE), 2007.
50. L. de Moura and N. Bjorner, *Model-based Theory Combination*, Workshop on Satisfiability Modulo Theories (SMT), 2007.
51. C. Barrett, L. de Moura and A. Stump, *Design and Results of the Second Satisfiability Modulo Theories Competition (SMT-COMP 2006)*, Journal of Formal Methods in System Design, 2007.
52. L. de Moura, B. Dutertre and N. Shankar, *A Tutorial on Satisfiability Modulo Theories*, Conference on Computer Aided Verification (CAV), 2007.
53. B. Dutertre and L. de Moura, *A Fast Linear-Arithmetic Solver for DPLL(T)* 18th International Conference on Computer Aided Verification (CAV'06).
54. C. Barrett, L. de Moura and A. Stump, *Design and Results of the 1st Satisfiability Modulo Theories Competition (SMT-COMP 2005)* Journal of Automated Reasoning (JAR), 2006.
55. C. Barrett, L. de Moura and A. Stump, *SMT-COMP: Satisfiability Modulo Theories Competition* 17th International Conference on Computer Aided Verification (CAV'05).
56. G. Hamon, L. de Moura and J. Rushby, *Generating Efficient Test Sets with a Model Checker*, The Second IEEE International Conference on Software Engineering and Formal Methods (SEFM'04).
57. L. de Moura, H. Rueß and N. Shankar, *Justifying Equality*, Second Workshop on Pragmatics of Decision Procedures in Automated Reasoning (PDPAR'04).
58. L. de Moura, S. Owre, H. Rueß, J. Rushby, N. Shankar, M. Sorea and A. Tiwari, *SAL 2*, 16th International Conference on Computer Aided Verification (CAV'04).

59. L. de Moura and H. Rueß, *An Experimental Evaluation of Ground Decision Procedures*, 16th International Conference on Computer Aided Verification (CAV'04).
60. L. de Moura, H. Rueß, N. Shankar and J. Rushby, *The ICS decision procedures for embedded deduction*, Second International Joint Conference on Automated Reasoning (IJCAR'04).
61. H. Rueß and L. de Moura, *From Simulation to Verification (and Back)* Proceedings of the 2003 Winter Simulation Conference.
62. L. de Moura, H. Rueß, J. Rushby and N. Shankar, *Embedded Deduction with ICS*, Presented at the third High Confidence Software and Systems Conference, 2003.
63. L. de Moura, H. Rueß and M. Sorea, *Bounded Model Checking and Induction: From Refutation to Verification*, 15th International Conference on Computer Aided Verification (CAV'03).
64. L. de Moura, H. Rueß and M. Sorea, *Lazy Theorem Proving for Bounded Model Checking over Infinite Domains*, International Conference on Automated Deduction (CADE'02).
65. L. de Moura, C.J. P. de Lucena and E.H. Haeusler, *Analysis of Parallel Programs*, Eletronic Notes in Theoretical Computer Science, 2002.
66. L. de Moura and H. Rueß, *Lemmas on Demand for Satisfiability Solvers*, Fifth International Symposium on the Theory and Applications of Satisfiability Testing (SAT), 2002.
67. L. de Moura, *Semantic-Directed Generation of Program Analysis and Verification Tools*, Second Prize in the ACM'2000 Student Research Contest, Austin, Texas, 2000.
68. L. de Moura, C. J. P. de Lucena and E. H. Hausler, *Analysis of Parallel Programs*, Brazilian Symposium of Programming Languages (SBLP), 2000.
69. L. de Moura, C. J. P. de Lucena and E. H. Hausler, *A Modular Implementation of Action Notation*, International Workshop on Action Semantics and Related Frameworks, 2000.
70. M. F. Fontoura, C. Braga, L. de Moura and C. J. P. de Lucena, *Using Domain Specific Languages to Instantiate Object-Oriented Frameworks*, IEE Proceedings - Software, 147(4), 2000.
71. M. F. Fontoura, L. de Moura, S. Crespo and C. J. P. de Lucena, *ALADIN: An Architecture for Learningware Application Design and Instantiation*, World Wide Web WWW Baltzer Science, Bussum, Holand, 2000.



72. I. D. Baxter, A. Yahin, S. Nedunuri, and L. de Moura, *Lowering Maintenance Costs by Code Clone Removal*, 12th International Software Quality Week, 1999.
73. L. de Moura, C. J. P. de Lucena and A. von Staa, *The Spider Environment*, Software Practice & Experience, 29(2), 99-124, 1999.
74. I. D. Baxter, A. Yahin, L. de Moura, M. Sant'Anna and L. Bier, *Clone Detection Using Abstract Syntax Trees*, Proc. of the International Conference on Software Maintenance'98, 1998, IEEE Press.
75. L. de Moura and C. J. P. de Lucena, *An Introduction To The Spider Visual Programming Environment*, Brazilian Symposium of Software Engineering (SBES), 1997.
76. H. Fuks and L. de Moura, *Supporting Team Collaboration*, SIGOIS Bulletin 16, New York, pp.64-68, 1995.
77. H. Fuks and L. de Moura, *A Document Based Approach for Cooperation*, Journal of the Brazilian Computer Society, V1, N1, pp 36-45, July 1994.
78. L. de Moura and R. R. dos Santos, *Critical Exponents for Site-Bond Correlated Percolation*, Phys. Review B 45, 1023, 1992.

## Patents

- L. de Moura and N. Bjorner, *Matching based pattern inference for SMT solvers*, US Patent 9,489,221.
- L. de Moura and N. Bjorner, *Relevancy propagation for efficient theory combination*, US Patent 8,140,459.
- L. de Moura and N. Bjorner, *E-matching for SMT solvers*, US Patent 8,103,674.
- L. de Moura and N. Bjorner, *Model-based theory combination*, US Patent 7,925,476.
- J. Rushby, L. de Moura, G. Hamon, *Formal methods for test case generation*, US Patent 7,865,339.
- L. de Moura and H. Rueß, *Method for combining decision procedures with satisfiability solvers*, US Patent 7,653,520.

## Professional Activities

- Chair of the 13th International Conference on Interactive Theorem Proving (ITP), 2022.

- Member of the Program Committee of the 23rd International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI), 2021.
- Member of the Program Committee of the International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2021.
- Member of the Program Committee of the 12th International Conference on Interactive Theorem Proving (ITP), 2021.
- Member of the Program Committee of the 10th International Joint Conference on Automated Reasoning (IJCAR), 2020.
- Member of the Program Committee of the 23rd Brazilian Symposium on Formal Methods (SBMF), 2020.
- Member of the Program Committee of the 28th International Conference on Automated Reasoning with Analytic Tableaux and Related Methods (Tableaux), 2019.
- Member of the Program Committee of the International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2019.
- Member of the Program Committee of the 10th International Conference on Interactive Theorem Proving (ITP), 2019.
- Member of the Program Committee of the 25th International Conference on Types for Proofs and Programs (TYPES), 2018.
- Member of the Program Committee of the 9th International Joint Conference on Automated Reasoning (IJCAR), 2018.
- Member of the Program Committee of the 9th International Conference on Interactive Theorem Proving (ITP), 2018.
- Chair of 26th International Conference on Automated Deduction, 2017.
- Member of the Program Committee of the 24th International Conference on Types for Proofs and Programs (TYPES), 2017.
- Member of the Program Committee of the 26th International Conference on Automated Reasoning with Analytic Tableaux and Related Methods, 2017.
- Chair of the Calculemus track at Conference on Intelligent Mathematics, 2016.
- Member of the Program Committee of the International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2016.

- Member of the PhD Committee for Soonho Kong, Carnegie Mellon University, 2015.
- Member of the Program Committee of the NASA Formal Methods Symposium (NFM), 2015.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2015.
- Member of the Masters thesis committee for Robert Lewis, Carnegie Mellon University, 2014.
- Member of the Program Committee of the International Conference on Automated Deduction (CADE, 2014).
- Member of the Program Committee of the International Conference on Automated Deduction (CADE, 2013).
- Member of the Program Committee of the International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2013.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2013.
- Member of the PhD committee for Chantal Keller, École Polytechnique, 2013.
- Member of the Program Committee of the 5th NASA Formal Methods Symposium (NFM), 2013.
- Chair of the 16th Brazilian Symposium on Formal Methods (SBMF), 2013.
- Member of the PhD committee for Dejan Jovanović, New York University, 2012.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2012.
- Member of the Program Committee of the International Symposium on Formal Methods (FM), 2012.
- Member of the Program Committee of the International Conference on Verified Software: Theories, Tools, and Experiments (VSTTE), 2012
- Member of the Program Committee of the International Conference on Automated Deduction (CADE, 2011).
- Member of the Program Committee of the Workshop on Satisfiability Modulo Theories (SMT), 2011.

- Member of the PhD committee for Christoph Wintersteiger, ETH Zurich, Switzerland, 2011.
- Member of the Program Committee of the Symposium on Logic in Computer Science (LICS), 2011.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2011.
- Member of the Steering Committee of the Workshop on Satisfiability Modulo Theories (SMT), 2009-2011.
- Member of the PhD committee for Alberto Griggio, University of Trento, Italy, 2010.
- Member of the Program Committee of the International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS), 2010.
- Member of the PhD committee for Yeting Ge, New York University, 2009.
- Member of the Program Committee of the International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2009.
- Member of the Program Committee of the Workshop on Satisfiability Modulo Theories (SMT), 2009.
- Member of the Program Committee of the Workshop on Automated Formal Methods (AFM), 2009.
- Member of the Program Committee of the Workshop on Automated Formal Methods (AFM), 2008.
- Member of the Program Committee of the International Conference on Frontiers of Combining Systems (FroCoS), 2008.
- Chair of the Workshop on Satisfiability Modulo Theories (SMT), 2008.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2008.
- Member of the Program Committee of the Workshop on Bit-Precise Reasoning (BPR), 2008.
- Member of the Program Committee of the Workshop on Automated Formal Methods (AFM), 2007.
- Member of the Program Committee of the Workshop on Satisfiability Modulo Theories (SMT), 2007.
- Member of the Program Committee of the International Conference on Satisfiability (SAT), 2007.

- Organizer of the 2nd Satisfiability Modulo Theories Competition (SMT-COMP), 2006.
- Member of the Program Committee of the International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2006
- Member of the Program Committee of Pragmatics of Decision Procedures in Automated Reasoning (PDPAR), 2006.
- Tutorial Chair of the International Conference on Formal Methods in Computer-Aided Design (FMCAD), 2006.
- Organizer of the 1st Satisfiability Modulo Theories Competition (SMT-COMP), 2005.

## References

### **Dr. Thomas Ball**

Microsoft Research, WA, USA

email: [tball@microsoft.com](mailto:tball@microsoft.com)

homepage: <https://www.microsoft.com/en-us/research/people/tball/>

### **Prof. Jeremy Avigad**

Carnegie Mellon University, PA, USA

email: [avigad@cmu.edu](mailto:avigad@cmu.edu)

homepage: <http://www.andrew.cmu.edu/user/avigad/>

### **Dr. Natarajan Shankar**

SRI International, CA, USA

email: [shankar@csl.sri.com](mailto:shankar@csl.sri.com)

homepage: <http://www.csl.sri.com/~shankar>