

# Vita for Jean H. Gallier

May 28, 2009

## 1 Personal Data

Work address: Department of Computer and Information Science  
GRW, Room 476  
University of Pennsylvania  
Philadelphia, Pa 19104  
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Philadelphia, Pa 19104  
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Date and Place  
of Birth: January 5, 1949; Nancy 54, France

Citizenship: US & French

### Education

High School and Undergraduate education in France.

Baccalaureat: Lycée de Sèvres, Sèvres, France (July 1966).

Ingenieur Civil des Ponts et Chaussées, July, 1972  
Ecole Nationale des Ponts et Chaussées, (Civil Engineering)  
Paris, France

Ph.D., June, 1978, (Computer Science)  
University of California, Los Angeles  
Los Angeles, California  
S. A. Greibach and E. P. Friedman, supervisors

**Academic Record**

- 2006-2007      On sabbatical at INRIA, Sophia Antipolis  
2004, route des Lucioles, B.P. 93  
06902 Sophia Antipolis Cedex  
France
- 2001-2004      Director of the French Institute  
of Culture and Technology
- 1994-present    Secondary Appointment in Mathematics
- 1990-present    Professor
- 1990-1991      On sabbatical at Digital PRL  
85, avenue Victor-Hugo  
92563 Rueil-Malmaison Cedex  
France
- 1984-1990      Associate Professor
- 1988-1990      Graduate Chair
- 1978-1984      Assistant Professor  
Department of Computer and Information Science  
University of Pennsylvania  
Philadelphia, Pennsylvania
- 1977-1978      Lecturer and Postdoctoral Research Position  
Department of Mathematics and Computer Science Program  
University of California, Santa Barbara
- 1974-1977      Research Assistant, System Science Department  
University of California, Los Angeles
- 1973-1974      Teaching Assistant, Computer Science Department  
University of California, Los Angeles

**References upon request**

## 2 Publications

### 2.1 Papers accepted in refereed Journals

- [1] On the Existence of Optimal Fixed Points. *Mathematical Systems Theory* 13, 209-217 (1980).
- [2] Nondeterministic Flow Chart Programs with Recursive Procedures: Semantics and Correctness I. *Theoretical Computer Science* 13(2), 193-224 (1981).
- [3] Nondeterministic Flow Chart Programs with Recursive Procedures: Semantics and Correctness II. *Theoretical Computer Science* 13(3), 239-270 (1981).
- [4] DPDA's in "Atomic Normal Form" and Application to Equivalence Problems. Special issue of *Theoretical Computer Science* 14(2), 155-186 (1981).
- [5] Recursion-closed Algebraic Theories. *Journal of Computer and System Sciences* 23(1), 69-105 (1981).
- [6]  $n$ -Rational Algebras, Part I: Basic Properties and Free Algebras. *SIAM on computing* 13(4), 750-775 (1984).
- [7]  $n$ -Rational Algebras, Part II: Varieties and Logic of Inequalities. *SIAM on computing* 13(4), 776-794 (1984).
- [8] Linear-time algorithms for testing the satisfiability of propositional Horn Formulae. (With William Dowling). *Journal of Logic Programming* 1(3), 267-284 (1984).
- [9] Reductions in Tree Replacement Systems. (With Ronald Book). *Theoretical Computer Science* 37(2), 123-150 (1985).
- [10] Tree Pushdown Automata. (With Karl Schimpf). *Journal of Computer and System Sciences* 30(1), 25-40 (1985).
- [11] Continuation Semantics for Flowgraph Equations. (With William Dowling). *Theoretical Computer Science* 44(3), 307-331 (1986).
- [12] HORNLOG: A Graph Based Interpreter for General Horn Clauses. (With Stan Raatz). *Journal of Logic Programming* 4(2), 119-155 (1987).
- [13] Fast Algorithms for Testing Unsatisfiability of Ground Horn Clauses with Equations. *Journal of Symbolic Computation* 4, 233-254 (1987).
- [14] Decidable Subcases of the Equivalence Problem for Recursive Program Schemes. (With Bruno Courcelle). *RAIRO Informatique Theorique* 21(3), 245-286 (1987).

- [15] Building Exact Computation Sequences. (With Alex Pelin). *Theoretical Computer Science* 53(1), 125-150 (1987).
- [16] Extending SLD-Resolution to Equational Horn Clauses using  $E$ -Unification. (With Stan Raatz). Special issue of *Journal of Logic Programming* 6(1-2), 3-56 (1989).
- [17] Complete Sets of Transformations For General  $E$ -Unification. (With Wayne Snyder). Special issue of *Theoretical Computer Science* 67(2-3), 203-260 (1989).
- [18] Higher-Order Unification Revisited: Complete Sets of Transformations. (With Wayne Snyder). Special issue of *Journal of Symbolic Computation* 8(1-2), 101-140 (1989).
- [19] Rigid  $E$ -Unification: NP-completeness and Applications to Theorem Proving. (With P. Narendran, David Plaisted, and Wayne Snyder). Special issue of *Information and Computation* 87(1/2), 129-195 (1990).
- [20] What's so Special about Kruskal's Theorem and the Ordinal  $\Gamma_0$ ?, A Survey of Some Results in Proof Theory. *Annals of Pure and Applied Logic*, Vol. 53, 199-260 (1991).
- [21] Theorem Proving Using Equational Matings and Rigid  $E$ -Unification. (with Paliath Narendran, Stan Raatz, and Wayne Snyder). *J.ACM* Vol. 39, No. 2, 377-429 (April 1992).
- [22] Polymorphic Rewriting Conserves Algebraic Strong Normalization. (With Val Breazu-Tannen). Special issue of *Theoretical Computer Science* 83(1), 3-28 (1991).
- [23] An Algorithm for Finding Canonical Sets of Ground Rewrite Rules in Polynomial Time. (With Paliath Narendran, David Plaisted, Stan Raatz, and Wayne Snyder). *J.ACM*, Vol. 40, No. 1, 1-16 (1993).
- [24] Constructive Logics. Part I: A Tutorial on Proof Systems and Typed  $\lambda$ -Calculi, *Theoretical Computer Science* 110(2), 249-339 (1993).
- [25] Polymorphic Rewriting Conserves Algebraic Confluence. (With Val Breazu-Tannen). *Information and Computation*, Vol. 14, No. 1, 1-29, (1994).
- [26] Proving Properties of Typed  $\lambda$ -Terms Using Realizability, Covers, and Sheaves, *Theoretical Computer Science* 142(2), 299-368, (1995).
- [27] Kripke Models and the (in)equational logic of the second-order lambda-Calculus. *Annals of Pure and Applied Logic* 84, 257-316, (1997).
- [28] Typing untyped lambda terms, or Reducibility Strikes Again! *Annals of Pure and Applied Logic* 91, 231-270, (1998).
- [29] A Simple Method For Drawing a Rational Curve as Two Bezier Segments. *ACM Transactions on Graphics*, Vol. 18, No. 4, pp. 316-328 (1999).

- [30] Simple Methods For Drawing Whole Rational Surfaces as Four or Six Bézier Patches. To appear in *ACM Transactions on Graphics*, 2007. Posted on ArXiv as paper cs.CG/0606055.
- [31] Computing Exponentials of Skew-Symmetric Matrices And Logarithms of Orthogonal Matrices. With Dianna Xu. *International Journal of Robotics and Automation*, Vol. 18, No. 1, 2003, pp. 10-20.
- [32] Deterministic Finite Automata with Recursive Calls and DPDA's. With Salvatore La Torre and Supratik Mukhopadhyay. *Information Processing Letters*, 87, 2003, pp. 187-193.
- [33] A Kinematic Model of the Human Arm Using Triangular Bézier Spline Surfaces. With Deepak Tolani and Norman Badler. *GMIP*, to appear.
- [34] Constrained Quadrilateral Meshes of Bounded Size, (with S. Ramaswami, M. Siqueira, T. Sundaram, and J. Gee), *International Journal of Computational Geometry and Its Applications*, Vol. 15, No. 1, 2005, pp. 55-98.
- [35] The Completeness of Propositional Resolution: A Simple and Constructive Proof. *Logical Methods in Computer Science*, Vol 2 (5:3), 2006, pp. 1-7. Posted on ArXiv as paper cs.CG/0606084.
- [36] Topological Repairing of 3D Digital Images. (With M. Siqueira, L.J. Latecki, N. Tustison and J. Gee), *Journal of Mathematical Imaging and Vision*, Vol 30, No. 3, 2008, pp. 249-274.
- [37] A new construction of smooth surfaces from triangle meshes using parametric pseudo-manifolds (with Marcelo Siqueira, Dianna Xu, Luis Nonato, Dimas Morera and Luiz Velho) *Computers and Graphics*, Vol. 33, No. 3, 2009, pp. 331-340.

## 2.2 Papers submitted to refereed Journals

- [38] On the Efficiency of Strategies for Subdividing Polynomial Triangular Surface Patches. June 2006, posted on ArXiv as paper cs.CG/0606061.
- [39] Fast and Simple Methods for Computing Control Points, (with Weiqing Gu). June 2006, posted on ArXiv as paper cs.CG/0606056.
- [40] On the Efficiency of Strategies for Subdividing Polynomial Triangular Surface Patches. June 2006, posted on ArXiv as paper cs.CG/0606061.
- [41] Remarks on the Cayley representation of orthogonal matrices and on making matrices invertible by perturbing the diagonal. June 2006, posted on ArXiv as paper math.NA/0606320.

### 2.3 Refereed Conference Proceedings

- [42] Semantics and Correctness of Nondeterministic Flow Chart Programs with Recursive Procedures. In: *Automata, Languages and Programming*, Fifth Colloquium, Udine, Lecture Notes in Computer Science, Vol. 61, 251-267 (July 1978).
- [43] Recursion Schemes and Generalized Interpretations. In: *Automata, Languages, and Programming*, Sixth Colloquium, Graz, Lecture Notes in Computer Science, Vol. 71, 256-269 (July 1979).
- [44] Building Friendly Parsers. (With Fahimeh Jalili). *Ninth POPL Conference*, Albuquerque, New Mexico, 196-206 (January 1982).
- [45] Solving Word Problems in Free Algebras Using Complexity Functions. (With Alex Pelin). Proceedings of the *Seventh International Conference on Automatic Deduction*, Napa Valley, California, 476-495 (May 1984).
- [46] Graph-Based Logic Programming Interpreters. (With Stan Raatz). Proceedings of the *2nd Symposium on Logic Programming*, Boston, Mass, 208-219 (July 1985).
- [47] Exact Computation Sequences. (With Alex Pelin). Proceedings of *CAAP'86*, Sophia Antipolis, France, 45-59 (March 1986).
- [48] SLD-Resolution Methods for Horn Clauses with Equality Based on  $E$ -unification. (With Stan Raatz). Proceedings of the *Third Symposium on Logic Programming*, Salt Lake City, Utah, 168-179 (September 1986).
- [49] Theorem Proving Using Rigid  $E$ -Unification: Equational Matings. (with Stan Raatz and Wayne Snyder). *LICS'87*, Cornell, Ithaca, 338-346 (June 1987).
- [50] A General Complete  $E$ -Unification Procedure. (with Wayne Snyder). *RTA'87*, Bordeaux, France, 216-227 (May 1987).
- [51] Rigid  $E$ -Unification is NP-complete. (With P. Narendran, David Plaisted, and Wayne Snyder). *LICS'88*, Edinburgh, Scotland, 218-227 (1988).
- [52] Finding Canonical Rewriting Systems Equivalent to a Finite Set of Ground Equations in Polynomial Time. (With P. Narendran, D. Plaisted, and W. Snyder). *CADE'88*, Argonne National Laboratory, Illinois, 182-196 (1988).
- [53] A Relational Semantics for Logic Programming. (With Stan Raatz). *5th International Conference Symposium on Logic Programming*, University of Washington, Seattle, 1024-1035 (August 1988).

- [54] Rewriting in Order-Sorted Equational Logic. (With Tomas Isakowitz). *5th International Conference Symposium on Logic Programming*, University of Washington, Seattle, 280-294 (August 1988).
- [55] Polymorphic Rewriting Conserves Algebraic Strong Normalization and Confluence. (with Val Breazu-Tannen). In *Automata, Languages and Programming*, 16th Colloquium, Stresa, Lecture Notes in Computer Science, Vol. 372, 137-150 (July 1989).
- [56] Topological Evolution of surfaces (with Doug De Carlo). *Graphics Interface '96*, Toronto, Canada, May 1996.
- [57] Drawing Closed Rational Surfaces. *13th Annual ACM Symposium on Computational Geometry*, Nice, France, June 1997.
- [58] Incremental Algorithms for The Design Of Triangular-Based Spline Surfaces (with Dianna Xu). *SIAM Conference on Geometric Design and Computing*, November 5-8, 2001, Sacramento, California.
- [59] Quadrilateral Meshes for the Registration of Human Brain Images. (with M. Siqueira, T. Sundaram, S. Ramaswami, and J. Gee). Abstracts of the *DIMACS Workshop on Medical Applications in Computational Geometry*, DIMACS Center, Rutgers University, New Brunswick, NJ, USA, April 2-4, 2003.
- [60] A New Algorithm for Generating Quadrilateral Meshes and Its Application to FE-Based Image Registration (with S. Ramaswami, M. Siqueira, T. Sundaram and J. Gee). Proceedings of the *12th International Meshing Roundtable*, Santa Fe, New Mexico, September, 2003.
- [61] Making 3D Binary Digital Images Well-Composed (with M. Siqueira, L. J. Latecki). Proceedings of the *IS&T/SPIE 17th Annual Symposium Electronic Imaging, Vision Geometry XIII*, San Jose, California, USA, 2005, 150-160.
- [62] Generation of Smooth Surfaces from Binary Images (with M. Siqueira). *SIAM Conference on Geometric Design and Computing*, October 30-November 3, 2005, Phoenix, Arizona.
- [63] A new construction of smooth surfaces from triangle meshes using parametric pseudo-manifolds (with Marcelo Siqueira and Dianna Xu). *Shape Modeling International*, Beijing China, June 2009.

## 2.4 Book Chapters

- [64] The Semantics of Recursive Programs with Function Parameters of Finite Types:  $n$ -rational Algebras and Logic of Inequalities. In *Algebraic Methods in Semantics*, Maurice Nivat and John Reynolds, editors, Cambridge University Press, 313-362 (1985).
- [65] Rigid  $E$ -Unification and its Applications to Equational Matings. (with Stan Raatz and Wayne Snyder). *Resolution of Equations in Algebraic Structures*, Ait-Kaci and Nivat, editors, Academic Press, 151-216 (1989).
- [66] On Girard's "Candidats de Reductibilité." In *Logic and Computer Science*, Odifreddi, editor, Academic Press, 123-203 (1990).
- [67] Designing Unification Procedures Using Transformations: A Survey. (With Wayne Snyder). In *Logic from Computer Science*, Iannis Moschovakis, editor, Springer Verlag, 153-215 (1991)
- [68] A Proof of Strong Normalization For the Theory of Constructions Using a Kripke-Like Interpretation. (With Thierry Coquand). Proceedings of the First Annual Workshop on Logical Frameworks, Esprit Basic Research Action, Antibes, May 7-11, 1990, Gerard Huet, editor.
- [69] Unification Procedures in Automated Deduction Methods Based on Matings: A Survey. In *Tree automata and languages*, Edited by M. Nivat and A. Podelski, Elsevier, 439-485 (1992).
- [70] On the Correspondence Between Proofs and  $\lambda$ -Terms. *Cahiers du Centre de Logique*, Philippe DeGroote, Editor, Université Catholique de Louvain, 1995.

## 2.5 Books

- [71] *Logic for Computer Science: Foundations of Automatic Theorem Proving*, Wiley, pp. 511 (1986).
- [72] *Curves and Surfaces In Geometric Modeling: Theory And Algorithms*. Morgan Kaufmann, pp. 491 (1999).
- [73] *Geometric Methods With Applications to Computer Science and Engineering*. Springer Verlag, pp. 565, TAM No. 38, November 2000.

## 2.6 Papers, book chapters, and books in Preparation

- [74] *The Classification Theorem for Compact Surfaces* (with Dianna Xu). Book manuscript, submitted to AMS, 2009.

- [75] A Note on Logical PERs and Reducibility. Logical Relations strike again! Technical Report, July 1996.
- [76] A Concrete Introduction to Classical Lie Groups Via the Exponential Map. Technical Report, March 1999.
- [77] *Algebra* (with Stephen S. Shatz). Book manuscript, submitted to AMS, expected completion, 2010.
- [78] *Algebraic Geometry* (with Stephen S. Shatz). Book in progress, expected completion, 2010.
- [79] Incremental Algorithms for the Design of Open  $C^1$  Triangular Spline Surfaces (With Dianna XU), November 2005.
- [80] Construction of  $C^\infty$ -Surfaces from Triangular Meshes Using Parametric Pseudo-Manifolds (with Marcelo Siqueira and Dianna Xu), May 2009.
- [81] *Notes on Differential Geometry and Lie Groups*. Book in progress, expected completion, 2010.
- [82] *Convex sets, Polytopes, Combinatorial Topology, Voronoi Diagrams and Delaunay Triangulations*. Book in progress, expected completion, 2009.
- [83] *Discrete Mathematics, Some Notes*. Book in progress, expected completion, 2010.

## 2.7 Technical Reports

- [84] Deterministic Finite Automata with Recursive Calls and DPDA's (1983).
- [85] Implementation of an Incremental Compiler. (With Michael Tiemann) (1985).
- [86] Merged LR(1)-parser generators with built-in error automata. (With Frank Manion and Karl Schimpf) (1985).
- [87] CISV3: A Compiler Generator Based on Attribute Evaluation. (With Frank Manion and John McEnerney) (1987).
- [88] Constructive Logics. Part II: Linear Logic and Proof Nets, Technical Report No. 9, Digital PRL, Rueil-Malmaison, France (1991).
- [89] Realizability, Covers, and Sheaves. I. Applications to the Simply-Typed  $\lambda$ -Calculus. Technical Report, April 1993.
- [90] Realizability, Covers, and Sheaves. II. Applications to the Second-Order Typed  $\lambda$ -Calculus. Technical Report, April 1993.

- [91] Quadrilateral Meshes for Finite Element-Based Image Registration (with M. Siqueira, T. Sundaram, S. Ramaswami, and J. Gee). Technical Report MS-CIS-03-16, Department of Computer and Information Science, University of Pennsylvania, Philadelphia, USA, 2003.
- [92] Making 3D Binary Digital Images Well-Composed (with M. Siqueira and L. J. Latecki). Technical Report MS-CIS-04-22, Department of Computer and Information Science, University of Pennsylvania, Philadelphia, PA, USA, 2004.
- [93] Notes on Convex sets, Polytopes, Polyhedra, Combinatorial Topology, Voronoi Diagrams and Delaunay Triangulations. INRIA Technical Report No. 6379, December 2007.
- [94] Logarithms and Square Roots of Real Matrices. Technical Report MS-CIS-08-12, Department of Computer and Information Science, University of Pennsylvania, Philadelphia, PA, USA, 2008.

## 2.8 Software

- [95] LR1GEN (with Karl Schimpf). This is a parser generator capable of computing LR-tables according to four methods: LALR(1), weak merged LR(1), strong merged LR(1), and full LR(1). It incorporates a corrected version of Pager's method for computing merged LR(1)-tables, and a simplified version of the "error automaton" due to DeRemer and Pennello. This tool has been used for teaching CSE341 and CIS675A, and by some Ph.D students in Professor Badler's graphics lab. A slightly modified version was used at RCA for designing a compiler for the language VERLANGEN, a hardware verification language comprising about 300 grammar rules. Grammars for PASCAL and C are easily accomodated.
- [96] CISV3 (with McEnerney, and Manion). This is an experimental compiler building tool, based on LR1GEN and an attribute evaluation algorithm due to Jalili, Gallier, and Manion. This tool has been used for teaching CSE341, CIS675A, and for designing some experimental compilers, such as HORNLOG. The system CISV3 was rewritten by Tiemann, who ported it to MCC (Austin, Texas), where it was used for designing hardware testing software.

## 3 Research Activities

### Grants

NSF Grant for 1982-1983, \$34,264 (Theory and Application of Rewriting Systems).

NSF Grant for 1986-1987, \$196,222 (Graph-Based Logic Programming Interpreters).

Co-PI on NSF CISE Equipment Grant, \$1,700,000 for five years, starting May 1989

Co-PI on an NSF-INRIA travel grant, \$62,000 for two years, starting May 1989.

ONR Grant for 1988-1992, \$150,000 (Unification and its Applications).

ONR Grant for 1993-1995, \$150,000 (The geometry of interaction program and its applications)

Co-PI on ARO MURI Grant for 1995-2000, \$2,383,464 (Algorithmics of Motion)

Co-PI on NSF Grant for 1999-2002, \$150,658 per year (Coupling deformable models and pixel affinity methods for medical image segmentation ...)

### General Description of Research Interests

Until three years ago, the unifying thread of my research interests has been the *semantics and logics of programs*. I have been interested in both applied and theoretical aspects of the semantics of programs and programming languages, and my work in these areas ranges from incremental parsing to proof theory and  $\lambda$ -calculus. In particular, I have contributed to the following areas: compiler generators, incremental parsing, attribute evaluation, program schemes, formal languages, tree automata, program verification, algebraic semantics, compiler correctness, continuation semantics, logic programming, automated theorem proving, rewrite systems, unification, proof theory, type theory and polymorphic  $\lambda$ -calculi, and constructive logics. I am also interested in algorithms for computational logic. I have designed some fast algorithms for ground Horn clauses with or without equality, and a fast algorithm for generating a canonical set of rewrite rules from a set of ground equations.

Following my Ph.D. work, for the first four years at the University of Pennsylvania, I have done research in program verification [2, 3, 42], equivalence problems for program schemes, and algebraic semantics [1, 4, 5, 6, 7, 11, 14, 43, 64]. In the following three years, I was increasingly interested in more applied topics such as, compiler generators and incremental compilers [44, 85, 86, 87], term-rewriting systems [9, 10, 45], automated theorem-proving and logic-programming [8, 12, 15, 46, 47]. I have also done work in logic programming, automated deduction [13, 16, 48, 49, 51, 52, 53, 54, 65, 23, 28, 19, 21, 27,

88, 20, 89], but also unification, and type theory and  $\lambda$ -calculus [17, 18, 50, 55, 66, 22, 25, 52]. For further details, see the Appendix (Research Interests).

Since 1993, I have been interested in geometry and its applications to computer science (3D graphics, computer vision, etc), geometric modeling, the geometry of curves and surfaces, motion planning, differential geometry, classical mechanics, optics. For further details, see the Appendix (Research Interests).

### **Future Plans**

Apply geometric modeling techniques to practical problems, notably modeling human organs (the heart, the eye, ...). Also investigate motion interpolation on curved spaces, 3D animation, motion planning, and 3D reconstruction problems in computer vision.

## **4 Awards**

Recipient of the Lindback Teaching Award,  
April 1983, University of Pennsylvania  
(Award given for distinguished teaching)

## **5 Teaching Activities**

### **Students Supervised**

#### *Ph.D. Dissertations Supervised:*

- Tom Myers, Infinite Structures in Programming Languages, 1980.
- Karl Schimpf, A Parsing Method for Context-free Tree Languages, 1982.
- Fahimeh Jalili, Design of Incremental Compilers, 1982.
- Will Dowling, Contributions to the Compiler Correctness Problem, 1984.
- Majid Naini, Attribute Evaluators and Attribute Machines, 1985.
- Stan Raatz, Aspects of a Graph-based Proof Procedure for Horn Clauses, 1987
- Wayne Snyder, Complete Sets of Transformations for General Unification, 1988.
- Tomas Isakowitz, Theorem Proving Methods for Order-Sorted Logic, August 1989.

- Jin Choi, The Decidability Problem for Rigid  $E$ -Unification: A New Proof and Extensions, May 1993.
- Dianna Xu, Incremental Algorithm for the Design of Triangular-Based Spline Surfaces, October 2002.
- Marcelo Siqueira, Mesh Generation from Imaging Data, February 2006.
- Gary Zhang, coadvised with Jim Gee, Methods in diffusion tensor registration, July 2007.

*Master's degree theses supervised:*

- Mohamed Beili, Implementation of an SLR(1)-parser constructor incorporating the forward-move error recovery scheme of DeRemer and Pennello, 1979.
- Dan Sacks, LEX: A lexical Analyzer Constructor, 1980.
- Karl Schimpf, Construction Methods of LR parsers, 1981.
- Frank Manion, An Attribute Grammar Based Compiler Generator for Unrestricted Conditional Attribute Grammars, 1984.
- Linda Small Plotnick, The Equivalence of Resolution and Gentzen Proof Systems for Propositional Logic, 1984.

*Note:* I have also supervised numerous senior projects.

### Courses Taught

- (Undergraduate) CSE 220, Algorithms and Data Structures, Average Enrollment: 90, Spring 1981.
- (Undergraduate) CSE 261, Mathematical Foundations of Computer Science, Average Enrollment: 80, Spring 1983, 1984.
- (Undergraduate) CSE 262, Introduction to the theory of computation Average Enrollment: 50, Fall 1992, 1993, 1994, 1995, 1996
- (Undergraduate) CSE 341, Compiler and Programming Language Design, Average Enrollment: 70, Each Fall.
- (Graduate) CIS 500, The Introductory graduate Computer Science course, Average enrollment: 40, Summer 1981, Summer 1982.
- (Graduate) CIS 510, Introduction to Geometric Methods in Computer Science Average enrollment: 16, Spring 1994, 1995, 1996, 1997

- (Graduate) CIS 511, Theory of Computation, Average enrollment: 50, Taught every year except 1990, 1998.
- (Graduate) CIS 578, Algebra for Computer Science, Average enrollment: 50, Taught three times.
- (Graduate) CIS 581, Logic for Computer Science, Average enrollment: 60, Taught four times.
- (Graduate) CIS 675A, Programming Languages and Compilers, Average enrollment 40, Taught six times.
- (Graduate) CIS 640, Seminar in the Theory of Computation. Average enrollment 25, Taught twice, Advanced Seminar.
- (Graduate) CIS 672, Automated Deduction. Average enrollment 25, Spring 1989, Advanced Course in Automated Deduction.
- (Graduate) CIS 610, Advanced Geometric Methods in Computer Science Average enrollment 9, Spring 1998,

#### *Class Notes*

I have written extensive sets of notes for CSE 261, CSE262, CSE 341, CIS 510, CIS511, CIS610, and CIS 578.

#### *Revising the Contents of Courses*

I was been actively involved in revising the contents of CSE 261, CIS510, CIS 578 and CIS 581, and with Dr. Buneman, in revising the Graduate Curriculum (the theory courses in particular).

#### **Other Teaching or Administrative Duties**

- Restructuring the theory courses for the Undergraduate Curriculum (with Dr. Gorn and Dr. Buneman)
- Restructuring the Master's Curriculum (with Dr. Buneman)
- The School of Engineering and Applied Science Academic Performance Committee (2 years)
- I served for five years as a member of the WPE (Written Preliminary Ph.D Exam), including once as Chairman.
- The Penn-Paris VI exchange program

- Graduate Students Admission (1986-1988)
- Graduate Chair (1988-present)
- Co-founder of the *Logic and Computation Group*, an interdisciplinary group including members from the computer and information science, mathematics, philosophy, and linguistics Departments.

## 6 Professional Activities

### Editorial Boards:

Member of the editorial board of the International Journal *RAIRO Informatique Theorique*, since 1983; J.E. Pin Editor in Chief.

Member of the editorial board of the *Journal of Symbolic Computation*, since 1988; B. Buchberger Editor in Chief.

Member of the editorial board of the *Journal of Logic Programming*, since 1989; J.L. Lassez Editor in Chief.

Member of the editorial board of *Theoretical Computer Science*, and special editor in charge of tutorials, since November 1992;

Editor of the new series *Progress in Theoretical Computer Science and Applied Logic*, Birkhauser Boston Inc., Publishers, since 1988.

### Conference Program Committees:

- *International Computer Science Conference '88*, Hong Kong, December 19-21, 1988.
- *RTA '89* (Rewriting Techniques and Applications), Chapell Hill, North Carolina, April 2-5, 1989.

### Conference Organization:

In charge of local arrangements for *LICS '90*, Philadelphia, 4-7, June 1990.

I am on the organizing committee for LICS (next 3 years).

I am on the organizing committee for RTA (next 3 years).

### Book Review:

I have reviewed the book *Elements of the Theory of Computation*, by Lewis and Papadimitriou, for the *Journal of Symbolic Logic* 49(3) 989-990 (1984).

### Refereeing:

I have refereed papers for the following Journals:

- SIAM Journal on Computing
- Theoretical Computer Science
- Journal of Computer and System Sciences
- Mathematical System's Theory
- Journal of the ACM
- Transactions on Programming Languages and Systems
- Journal of Logic Programming
- Journal of Symbolic Computation
- Journal of Symbolic Logic
- Journal of Automated Reasoning

I have refereed numerous NSF proposals and some proposals for ONR.

### Consulting:

I have consulted for the RCA Software Technology Laboratory, in Camden, New Jersey. This work dealt with:

- First-Order Logic Specification Languages
- First-Order Logic Theorem Proving
- High Level Language to Microcode Compilation

I assisted in writing a compiler for the language VERLANGEN, a hardware verification language.

### Professional Societies:

Member of A.C.M. (Association for Computing Machinery)

Member of SIGACT (Special Interest Group on Theory of Computation)

Member of A.M.S. (American Mathematical Society)

Member of A.S.L. (Association for Symbolic Logic)

Member of E.A.T.C.S. (European Association for Theoretical Computer Science)

Member of SIAM (Society for Industrial and Applied Mathematics)

## 7 Invited Speaker or Participant

- Invited speaker at the “Franco-American Seminar on the Application of Algebra to Language Definition and Compilation” (Fontainebleau, France, June 9-15, 1982). Talk on “Rational Algebras and Logic of Inequalities” and on “Incremental Evaluation for Attribute Grammars”.
- Invited speaker of the A.M.S. Toronto Meeting, Toronto, Canada, August 21-26, 1982), “Deterministic Finite Automata with Recursive Calls and DPDA’s”.
- Invited speaker at Workshop on Functional and Logic Programming, MCC, Austin, Texas, March, 1985.
- Invited speaker at the Workshop on Logic and Deductive Data Bases, Washington DC, August 1987, Refutation Methods for Equational Horn Clauses.
- Invited speaker at the Workshop on Unification Theory and Applications, Val d’Ajol, France, March 1987. Talks on General Unification via Transformations and Rigid Unification.
- Invited speaker at the Colloquium on the Resolution of Equations in Algebraic Structures, Austin, Texas, Theorem Proving Using Rigid  $E$ -Unification: Equational Matings, May 1987.
- Invited participant in the Conference on Categories in Computer Science and Logic, Boulder, Colorado, June 1987.
- Invited observer of the IFIP 2.2 Group, Sophia Antipolis, France, June, 1987.
- Invited participant at the Workshop on Categories in Computer Science and Logic, Boulder, Colorado, May 1988.
- Invited speaker at the Workshop on Unification Theory and Applications, Val d’Ajol, France, June 1988.
- Invited observer of the IFIP 2.2 Group, Warsaw, Poland, June, 1988.
- Invited speaker at *MAMLS’89*, Automated Theorem Proving Using Equational Matings and Rigid Unification, Philadelphia, PA, March 1989.
- Invited speaker at the “Ecole de Printemps” on logic and  $\lambda$ -calculus, Bruno Courcelle, organizer, Albi, France, April 1989.
- Invited speaker at the third Workshop on Unification theory, Kaiserslautern, Germany, June 1989.

- Invited observer of the IFIP 2.2 Group, Palo Alto, California, August 1989.
- Invited speaker at the Workshop “Logic From Computer Science”, Iannis Moskovakis, organizer, Berkeley, California, November, 13-17, 1989.
- Invited speaker at the First BRA Meeting, ESPRIT project, INRIA, Sophia Antipolis, France, Strong normalization proofs: From system  $F$ , through  $F_\omega$ , to the theory of constructions ( $CC$ ), May 7-11, 1990.
- Keynote speaker at the 2nd Workshop on conditional and typed rewriting systems (CTRS '90), Montreal, Canada, June 11-14, 1990.
- Invited speaker at the *Journées du L.I.P.N*, Paris, France, September 24-26, 1990.
- Invited Speaker at the Workshop “Mathematische Logik”, organized by W. Felscher (Tubingen), H. Schwichtenberg (Munich), and A.S. Troelstra (Amsterdam), Mathematical Center of Oberwolfach, December 16-22, 1990, A new method for proving strong normalization in the Coquand/Huet theory of constructions.
- Invited Speaker at the 5èmes Journées “Logique et Informatique”, Paris, France, January 23-24, 1991, Une méthode uniforme pour construire des algorithmes d’unification.
- Invited Speaker at the 5th Jumelage Meeting on Typed  $\lambda$ -Calculus, Paris, France, February 1-6, 1991, Combining Equational Reasoning With Typed  $\lambda$ -Calculi or Linear Logic.
- Invited Participant to the AMS-IMS-SIAM Joint Summer Research Conference in the Mathematical Sciences on “Graph Minors”, Seattle, Washington, June 22-July 5, 1991.
- Invited Speaker at the workshop on programming languages and category theory, Montreal, Canada, December 1991, Equational Reasoning in various logics.
- Invited Speaker at the third Jumelage Meeting, Cornell, Ithaca, October, 1992, A new proof of strong normalization for the theory of constructions.
- Invited Speaker at RTA'93 Montreal, Canada (1993). Proving properties of typed lambda-terms.
- Invited Speaker (Tutorial 3) at the XXI Symposium on Computer Graphics and Image Processing, Campo Grande, Brazil, October 2008.

## 8 Colloquia

- University of California, Los Angeles: “Verification of Recursive Flowchart Programs”, talk presented at the Southern California Seminar on Theoretical Computer Science, December, 1977.
- Stevens Institute of Technology, Hoboken, New Jersey, “Rational Algebras, Semantics and Logic of Inequalities”, February, 1982.
- I.B.M., T.J. Watson Research Center, Yorktown Heights, New York, “Rational Algebras, Semantics and Logic of Inequalities”, April, 1982.
- General Electric, Research and Development, Schenectady, New York, “Hornlog: A First-order Theorem-prover Based on Graph Rewriting”, December, 1984.
- IBM, T.J. Watson Research Center, Yorktown Heights, New York, “Hornlog: A First-order Theorem-prover Based on Graph Rewriting”, December, 1984.
- MCC, Austin, Texas, “CISV3: A Compiler Generator Based on Attribute Evaluation”, November, 1985.
- City University of New York, Extensions of SLD-resolution to equational Horn Clauses, May 1986.
- Georgetown University, SLDE-Resolution and  $E$ -unification based on Herbrand Transformations, October 1986.
- General Electric, Research and Development, Schenectady, New York, Refutation Methods for Equational Horn Clauses Based on  $E$ -Unification, January 1987.
- Carnegie Mellon University, General  $E$ -Unification via Transformations and Rigid  $E$ -Unification, April 1987.
- University of Kentucky, Refutation Methods for Equational Horn Clauses Based on  $E$ -Unification, April 1987.
- Duke University, Theorem Proving using Equational Matings and Rigid  $E$ -Unification, October 1988.
- Carnegie Mellon University, Combining Algebraic Rewriting With  $\beta, \eta$ -Reduction In the Polymorphic Typed Lambda Calculus, November 1988.
- Massachusetts Institute of Technology, Combining Algebraic Rewriting With  $\beta, \eta$ -Reduction In Polymorphic Typed Lambda Calculi, April 1989.
- Boston University, Combining Algebraic Rewriting With  $\beta, \eta$ -Reduction In Polymorphic Typed Lambda Calculi, April 1989.

- University of Bordeaux, France, Adding Algebraic Rewriting to Polymorphic Typed Lambda Calculi, April 1989.
- Stanford University, Adding Algebraic Rewriting to Polymorphic Typed Lambda Calculi, May 1989.
- SRI, Theorem Proving using Equational Matings and Rigid  $E$ -Unification, May 1989.
- University of California, Santa Barbara, A Survey on Automated Theorem Proving  $E$ -Unification, May 1989.
- State University of New York at Stony Brook, Adding Algebraic Rewriting to Polymorphic Typed Lambda Calculi, August 1989.
- Rutgers University, Mixing Computational Paradigms: Rewrite Rules and Polymorphism, February 1990.
- University of Paris VI, France, Mixing Computational Paradigms: Rewrite Rules and Polymorphism, March 1990.
- Digital PRL, Paris, France, A “Pot-pourri” of unification procedures, March 1990.
- Ecole Normale Supérieure, Paris, France, December 1990, Fonctions Calculables et Machines.
- LIENS, Ecole Normale Supérieure, Paris, France, January 1991, Confluence et normalisation pour les lambda-calculs typés avec règles de réécriture.
- Université Paris VI, Paris, France, January 1991, A proof of strong normalization for the theory of constructions using a Kripke-like interpretation.
- Université Paris Sud, LRI, Orsay, France, January 1991, Combining Equational Reasoning With Typed  $\lambda$ -Calculi or Linear Logic.
- Université Paris VII, Paris, France, March 1991, Theorem proving using equational matings.
- Université Paris VII, Paris, France, May 1992, Computational aspects of equational reasoning in various logics.
- LIENS, Ecole Normale Supérieure, Paris, France, May 1992, Computational aspects of equational reasoning in various logics.
- Inria, Paris, France, May 93, Reducibility, covers, and sheaves.
- Inria, Nancy, France, May 93, Reducibility, covers, and sheaves.
- Université Paris VII, Paris, France, December 1993, Reducibility, covers, and sheaves.

- Inria, France, May 94, Kripke models for second order  $\lambda$ -calculi.
- Princeton University, May 1997, Drawing rational curves and rational surfaces.
- LIENS, Ecole Normale Supérieure, France, January 98, Drawing rational curves and rational surfaces.
- Microsoft Research, June 1998, Algorithms for drawing rational curves and rational surfaces.

## 9 Appendix: Research Interests

### Semantics of programs and program verification:

The central problem addressed in my dissertation is to provide a sound and complete inductive assertion method for the class of nondeterministic flowchart programs with recursive procedures (with parameters passed by reference). I provided a complete (positive) solution to this problem, and gave various equivalent semantics for such a class of programs [2, 3, 42].

### Recursive Program Schemes and Equivalence Problems:

Having read the well known articles of B. Courcelle in which the equivalence problem for recursive program schemes is shown to be interreducible with the equivalence problem for Deterministic Pushdown Automata (DPDA's), I found a more direct construction not involving grammars [4], and I obtained some extensions.

### Algebraic Semantics of Recursive Program Schemes:

Inspired by work of Scott, Nivat, Courcelle, Guessarian, Wagner, Thatcher, Goguen and Wright, I became interested in algebraic semantics. One of the open problems was to generalize “rational algebraic theories” (and the corresponding algebras) to program schemes of higher types. The first step (context-free schemes) was achieved in [5] and [43]. A more significant step is achieved in [6, 7, 64], where classes of interpretations and the logic of inequalities for recursive program schemes with functions of higher types are investigated.

### Term-Rewriting Systems and Tree Grammars:

With Karl Schimpf, we were able to generalize a substantial part of the theory of LR-parsing to trees. Some of these results are reported in [10]. With A. Pelin, I have also investigated the problem of computing normal forms using complexity functions [15, 45, 47]. A method for reducing trees presented in [9] has been implemented in RRL by Kapur and Narendran, and they have reported that it runs faster than all other existing methods.

### Incremental Compilers and Attribute Evaluators:

With my Ph.D student Fahimeh Jalili, we have investigated the problem of incremental parsing. A new incremental parser was designed, which incorporates a simplified version of the error recovery scheme of DeRemer and Pennello using an “error automaton” [44, 95].

### **Logic Programming:**

I found a new algorithm for testing the satisfiability of propositional Horn formulae in linear time, and a fast algorithm for testing ground equational Horn clauses [8, 13]. This algorithm has been the source of inspiration for at least three papers (by other authors) on rule-based expert systems. Using this algorithm, I was able to design a procedure applying to arbitrary Horn clauses, that can be used as an interpreter for a class of logic programs containing PROLOG programs. I have implemented a prototype, HORNLOG, showing the feasibility of the method [12, 46]. With Stan Raatz, I have investigated several variants of SLD-resolution with equality, called SLDE-resolution [16, 48].

### **Unification:**

With Wayne Snyder, we showed that only one new transformation needs to be added to the transformations due to Martelli and Montanari, to obtain a complete  $E$ -unification procedure in the general case [17, 50]. Although this result is easy to state, the proof is very involved. We also reexamined the problem of general higher-order unification and developed an approach based on the method of transformations on systems of terms which has its roots in Herbrand’s thesis, and which was developed by Martelli and Montanari in the context of first-order unification [18].

### **Automated Deduction:**

With Wayne Snyder and Stan Raatz, I was able to find a suitable generalization of Andrews’s theorem proving method (matings), where equality is built-in [49, 19, 21]. The method remains complete even when a restricted form of  $E$ -unification is used. I was able to prove that rigid  $E$ -unification is decidable (conjectured at *LICS’87*), and also that rigid  $E$ -unification is NP-complete [51, 19, 65]. This result is technically quite difficult and extends significantly a result of Kozen. With Tomas Isakowitz, I have also been investigating order-sorted logic. Order-sorted algebras are one of the formalisms for dealing with subtypes and inheritance [28, 54].

### **Type theory and $\lambda$ -calculus:**

With Breazu-Tannen, we have investigated the combination of algebraic rewriting with  $\beta, \eta$ -reduction in the second-order polymorphic typed lambda calculus of Girard and Reynolds. We proved two difficult results [55, 22, 25]. The above work led me to take a hard look at Girard’s method for proving strong normalization in higher-order typed  $\lambda$ -calculi [66].

**Proof Theory (general):**

Some extensions of results of Gentzen to languages with equality are shown in my book [71]). In [20], I examine the significance of Kruskal's theorem.

**Geometry of curves and surfaces, and applications to graphics and computer vision:**

I have investigated fast algorithms for drawing closed rational curves and closed rational surfaces. In the case of curves, I found an algorithm that only needs to compute two control polygons from a given control polygon (of weighted points) specifying the curve. In the case of surfaces, I found an algorithm that only needs to compute six control nets from a given control net (of weighted points) specifying the surface. Furthermore, four of these nets are obtained by just flipping signs and permuting points. I have also investigated fast algorithms for recursively subdividing triangular surface patches. I designed an algorithm using only four calls to the de Casteljau algorithm. I am also interested in certain aspects of computational geometry, triangulations in particular. I am currently investigating fast methods for triangulating surfaces of arbitrary genus, and algorithms to modify such triangulations under changes of topology. I have worked on methods for specifying morphing of 3D shapes, with change of topology (for example, sphere to torus). I am currently writing a book titled *Geometric Methods in Computer Science. Algorithms for Curve and Surface Design and Representation*. This two volume book is primarily an introduction to geometric concepts and methods needed for solving various algorithmic problems having some geometric flavor.