

Stephanie Forrest

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🌐 <https://profsforrest.github.io/homepage>

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Education

University of Michigan <i>Ph.D. Computer and Communication Sciences</i>	Ann Arbor, MI 1985
University of Michigan <i>M.S. Computer and Communication Sciences</i>	Ann Arbor, MI 1982
St. John's College <i>B.A. (Liberal Arts, no major offered)</i>	Annapolis, MD and Santa Fe, NM 1977

Research Interests

Biology and computation, including computational immunology, genetic algorithms, computational modeling of biological systems, automated software repair, and biologically inspired approaches to computer security. Cybersecurity and cyberpolicy.

Employment

Arizona State University <ul style="list-style-type: none">○ Director, Biodesign Center for Biocomputation, Security and Society, 2017–present○ Professor of Computer Science, 2017–present	Tempe, AZ 2017–present
University of New Mexico <i>Dept. of Computer Science</i> <ul style="list-style-type: none">○ Distinguished Professor Emerita, 2017–present○ Distinguished Professor, 2013–2017○ Regents Professor, 2012–2017○ Dept. Chair, 2006–2011○ Professor, 1999–2013○ Associate Professor, 1994–1999○ Assistant Professor, 1990–1994○ Secondary appointment in Dept. of Biology, 2001–2017	Albuquerque, NM 1990–2017
Santa Fe Institute <ul style="list-style-type: none">○ Research Professor, part-time sabbatical leave, 2003–2006○ Interim Vice President for Academic Affairs, 1999–2000	Santa Fe, NM
Massachusetts Institute of Technology <i>Visiting Assoc. Professor (sabbatical leave)</i>	Cambridge, MA 1996–1997
Center for Nonlinear Studies, Los Alamos Nat. Laboratory <i>Director's Postdoctoral Fellow</i>	Los Alamos, NM 1988–1990
Teknowledge, Inc. <i>Scientist and Senior Scientist</i>	Palo Alto, CA 1985–1988

Honors and Awards

Test of Time Award <i>IEEE Security and Privacy Symposium</i> <i>A sense of self for Unix system calls</i> published in 1996	2020
Most Influential Paper Award <i>ACM/SIGSOFT and IEEE/TCSE</i> Most influential paper published at the 2009 Int. Conf. on Software Engineering (ICSE)	2019
Impact Award <i>ACM/SIGEVO</i> Highest impact paper published at the 2009 Conf. on Genetic and Evolutionary Computation (GECCO)	2019
IEEE Fellow	2015–present
Stanislaw Ulam Lectures <i>Santa Fe Institute</i> <ul style="list-style-type: none">◦ <i>Software engineering: Evolving computer programs</i>◦ <i>Immunology: The complex science of cyberdefense</i>◦ <i>Modeling computer networks from chips to the Internet</i>	2013
Jefferson Science Fellowship <i>National Academies of Science and Engineering</i>	2013–2014
Allen Newell Award <i>Association for Computing Machinery and AAAI</i>	2012
University of New Mexico <ul style="list-style-type: none">◦ <i>UNM 57th Annual Research Lecture</i> (2012)◦ <i>College of Engineering, Outstanding Research Award, Senior Faculty</i> (2000)◦ <i>General Library Faculty Acknowledgment Award</i> (1999)◦ <i>Regents Lecturer</i> (1994-97)◦ <i>College of Engineering, Outstanding Research Award Junior Faculty</i> (1993)	
Women in Technology Award <i>New Mexico Council on Technology</i>	2009
SIGEVO GECCO Impact Award <i>Association for Computing machinery</i> Highest impact paper published in the 1999 Genetic and Evolutionary Computation Conference	2009
Humies \$5000 Gold Medal Award <i>For human-competitive results produced by genetic and evolutionary computation</i>	2009
Manfred Paul Award for Excellence in Software: Theory and Practice <i>IFIP TC2</i>	2009
Senior Fellow <i>International Society for Genetic and Evolutionary Computation</i>	2003
St. John's College <i>Alumni Award of Merit</i>	2002
National Science Foundation <i>Presidential Young Investigator Award</i>	1991–1996
Association of Western Universities Faculty Fellowship <i>Faculty Fellowship</i>	1991
Young Faculty Award <i>GE Foundation</i>	1990

Selected Professional Activities

Computing Research Association

- Member Board of Directors, 2015–present
- Chair, Government Affairs Committee, 2016–present
- Member Computing Community Consortium (CCC) Council, 2009–2012

National Science Foundation

- CISE Advisory Committee, 2006–2008

Santa Fe Institute

- Science Board Co-Chair, 2010–2013
- Science Board Member, 1991–1997, 1998–2001, 2003–2008, 2009–2015
- Science Steering Committee, 1993–1999
- External Faculty, 1990–present
- Resident Faculty, 2003–2006

Defense Advanced Research Agency

- Information Science and Technology (ISAT) Advisory Group, 2001–2004

DIMACS

Advisory Committee for special focus on epidemiology

- Co-organizer of DIMACS working group on “analogies between computer viruses and immune systems and biological viruses and immune systems” (2001–2004)

Editing

- ACM Transactions on Evolutionary Learning and Optimization, Advisory Board, 2019–present
- Genetic Programming and Evolvable Machines (GPEM), Editorial Board, 2012–present
- Evolutionary Computation, Action and Associate Editor, 1994–2002, Advisory Board, 2002–present
- Artificial Life, Editorial Board, 1994–present
- Journal of Artificial Intelligence Research, Editorial Board, 1998–2002
- Evolutionary Intelligence, Editorial Board, 2007–present
- Journal of Machine Learning Research, Action Editor, 2005–2010
- Journal of Experimental and Theoretical Artificial Intelligence, Editorial Board, 1989–1996

Program Committees

- Intl. Conference on Software Engineering (ICSE), 2021
- Workshop on Economics of Information Security (WEIS), 2015–2016, 2020
- IEEE International Parallel and Distributed Processing Symposium (IPDPS), 2019
- ACM Conference on Computer and Communications Security, 2005
- New Security Paradigms Workshop, 2008
- Hot Topics in Operating Systems, 2005
- International Conference on Artificial Immune Systems, 2002–2008, 2011
- International Conference on Genetic Algorithms, 1991, 1993, 1995, 1997, 1999
- Genetic and Evolutionary Computation Conference, 2000, 2001, 2004, 2011
- Workshop on Foundations of Genetic Algorithms, 1992, 1994
- Second European Conference on Artificial Life, 1993
- International Conference on Intelligent Systems for Molecular Biology, 1994
- Parallel Problem Solving from Nature, 1994, 2012
- IEEE Conference on Evolutionary Computation, 1995
- International Joint Conference on Artificial Intelligence, 1995
- Scientific Advisory Board for the ALife 7 Conference, 2000, 2001

Funded Research

National Science Foundation

Machine Learning Inspired Single Molecule Biomarker Detection
M.P. Anantram (PI), S. Forrest, J. Hihath, and A. K. Das (co-PIs)

Submitted April 2022
\$1,495,000 (ASU share: \$475,000)

National Institutes of Health

SIMCoV: A spatially explicit model to predict SARS-CoV-2 lung infection

Submitted Feb. 2022
\$3,379,832 (ASU share: \$775,016)

M. Moses (PI), S. Forrest, J. Cannon, S. Bradfute (co-PIs)	
National Science Foundations	Submitted Dec. 2021
<i>Near-Hardware Program Repair and Optimization</i>	\$1,200,000 (ASU share: \$550,00)
W. Weimer (PI), S. Forrest and K. Angstadt (co-PIs)	
DARPA	Submitted Nov. 2021
<i>Euryale: Combating Emergent Execution with a GLANCE</i>	\$6,814,536
A. Doupe (PI), Y. Bao, S. Forrest, G. Pedrielli, Y. Shoshitaishvili, R. Wang, X. Xing, (co-PIs)	
Open Technology Fund	2021-2022
<i>Protecting at-risk populations from surveillance, censorship and targeted attacks</i>	\$246,078
J. Crandall (PI), S. Forrest (co-PI)	
Office of Naval Research	2021-2022
<i>GPU servers for computational biomaterial design, evolutionary GPU code</i>	\$121,831
P. Sulc (PI), S. Forrest (co-PI)	
National Science Foundation	2021-2024
<i>CICI:UCSS:Securing Data for Wastewater-based Epidemiology</i>	\$499,592
S. Forrest (PI), R. Halden, H. Lee, N. Trieu (co-PIs)	
National Science Foundation	2020-2021
<i>RAPID: Spatial Modeling of Imm. Response to SARS-Cov-2 Infection</i>	\$200,000 (ASU share: \$79,864)
M. Moses (PI), S. Forrest (co-PI)	
DARPA	2020-2024
<i>VOLT: A Viscous, Orchestrated Lifting and Translation Framework</i>	\$7,980,452
R. Wang(PI), S. Forrest and 5 others (co-PIs)	
National Science Foundation	2019-2022
<i>SHF: Understanding and Evolving Search-based Software Imprvmt.</i>	\$500,000 (ASU share: \$250,00)
S. Forrest (PI), W. Weimer (co-PI)	
Defense Advanced Research Projects Agency	2019-2022
<i>CHECRS: Cognitive Human Enhancements for Cyber Reasoning Systems</i>	\$11,730,557
R. Wang (PI), A. Bianchi, C. Baral, A. Doupe, S. Forrest, G. Vigna, Y. Shoshitaishvili (co-PIs)	
Air Force Research Laboratory	2019-2022
<i>Improving search-based and semantic automated prog. repair</i>	\$1,275,000 per year (ASU share per year: \$230,00)
W. Weimer (PI), S. Forrest C. Le Goues (co-PIs)	
Air Force Research Laboratory	2018-2019
<i>Trusted and resilient mission operation</i>	\$1,275,000 per year (ASU share per year: \$157,500)
W. Weimer (PI), J.Davidson, S. Forrest C. Le Goues, A. Paulos, E. Smith (co-PIs)	
National Science Foundation	2016-2021
<i>ADVANCE at UNM: Institute for Diversity and Equity Across STEM (IDEAS)</i>	\$3,358,125
J. Fulghum (PI), M.J Daniel, S. Forrest (withdrew 2017), P. Gonzales, M. Htun (co-PIs)	
Sandia Nat. Labs. Academic Alliance	2016-2017
<i>Applying Bio. Imm. Sys. Concepts to Improve Electronic Biosurveillance Sys. Performance</i>	\$50,000
S. Forrest (PI)	
National Science Foundation	2016-2017
<i>CS 10K: New Mexico Computer Science for All (NM CSforAll)</i>	\$169,407
(Subaward from Santa Fe Institute)	
National Science Foundation	2015-2018
<i>NeTS: Large: Measuring and Modeling Internet Choke Points as Threats to Online Freedom</i>	\$1,400,000
J. Crandall (PI), M. Faloutsos, S. Forrest (Co-PIs)	
Defense Advanced Research Projects Agency	2015-2018
<i>Double Helix: High-Assurance N-Variant Systems</i>	\$5,330,000 (UNM/ASU share: \$812,866)
J. Davidson (PI), S. Forrest, B. Dutertre (Co-PIs)	
Air Force Research Laboratory	2015-2017
<i>Cooperative, Trusted Software Repair for Cyber Physical System Resiliency</i>	\$899,948 (UNM share: \$216,000)

W. Weimer (PI), S. Forrest, M. Kim, C. LeGoues (co-PIs)

National Science Foundation EAGER **2014-2016**
SBE: Collab. Res.: Policies for Enhancing U.S. Leadership in Cyberspace \$201,129 (UNM Share: \$102,583)
S. Forrest (PI), R. Axelrod (co-PI)

Defense Advanced Research Projects Agency **2010-2015**
Scalable RADAR for Co-evolutionary Adversarial Environments \$3,200,625
S. Forrest (PI), J. Crandall, M. Moses, W. Weimer (Co-PIs)

National Science Foundation **2010-2013**
Collaborative Research: Search, Signals and Information Exchange in Distributed Biological Systems \$500,000
M. Moses (PI); S. Forrest, D. Gordon (Co-PIs)

Air Force Office of Scientific Research DURIP-10-054 **2010**
Helix Project Testbed: Towards the Self-Regenerative Incorruptible Enterprise \$58,189
S. Forrest (PI)

Department of Energy **2009-2012**
ASIM: An integrated agent-based model of a complex network UNM share: \$600,000
S. Hofmeyr (PI), S. Forrest (Co-PI)

National Science Foundation **2009-2012**
SHE: Medium: Collab. Res.: Fixing real bugs in real programs using evolutionary algorithms \$600,000
W. Weimer (PI), S. Forrest (Co-PI)

National Science Foundation **2007-2008**
Safe Computing Workshop: Introspective Hardware Architectures for Information Assurance \$69,930
S. Forrest (PI)

Air Force Office of Scientific Research MURI **2007-2012**
Helix: A Self-Regenerative Architecture for the Incorruptible Enterprise UNM Share: \$750,000
J. C. Knight (PI), J. Davidson, D. Evans, W. Weimer, A. Nguyen-Tuong, H. Chen, K. Levitt, J. Rowe, Z. Su, F. Wu, F. Chong, S. Forrest, J. Saia (Co-PI)

National Institutes of Health **2007-2009**
Modeling Early Influenza Virus Replication in Primary Human Lung Cells UNM Share: \$144,046
F. Koster (PI), S. Forrest (Co-PI)

National Science Foundation **2006-2009**
Collaborative Research: A Biologically Motivated Scaling Theory for Computing \$230,921
S. Forrest (PI), J. Brown, A. Davis (Co-PIs)

Howard Hughes Medical Institute **2006-2011**
Program in Interdisciplinary Biomedical Science (PIBS) \$1,000,000
J. Brown (PI), S. Forrest, N. Kenkre and F. Smith (Co-PIs).

Motorola **2005-2008**
Biological Design for Computer Security \$150,000
S. Forrest (PI)

SFI International Program **2005-2006**
Instruction Set Diversification \$17,500
G. Barrantes, J. Vargas, and S. Forrest (PIs)

UNM/LANL Joint Science and Technology Laboratory **2005-2007**
Realistic Modeling of the Immune Response in Tissue \$131,750
S. Forrest and A. S. Perelson (PIs)

National Institutes of Health **2003-2008**
COBRE Center for Evolutionary and Theoretical Immunology \$10,141,000
E. S. Loker (PI), S. Forrest, R. D. Miller, A. S. Perelson (Co-PIs)

National Science Foundation CCR Large ITR **2003-2008**
Sensitive Information in a Wired World \$12,500,000, UNM share: \$625,000
D. Boneh (PI), J. Feigenbaum, S. Forrest, and 5 others (Co-PIs)

National Science Foundation SGER	2003-2004
<i>Reconstructing Information from Database Fragments Via Negative Partial Match Detection</i>	\$100,000
S. Forrest (PI), P. Helman (Co-PI)	
National Science Foundation	2003-2007
<i>Automated and Adaptive Diversity for Improving Computer Sys. Sec.</i>	\$1,200,000, UNM Share: \$250,000
D. Song (PI), M. Reiter, S. Forrest (Co-PIs)	
Defense Advanced Research Projects Agency	2002-2003
<i>Automated Diversity in Computer Systems UNM Component</i>	\$280,000
S. Forrest (PI)	
National Institutes of Health	2002-2005
<i>P20 Center for the Spatiotemporal Modeling of Cell Signaling Planning Grant</i>	\$988,815
J. Oliver (PI), S. Steinberg, S. Forrest, and G. Heffelfinger (Co-PIs)	
Intel Corp.	2001-2003
<i>Information Immune Systems</i>	\$154,000
S. Forrest, PI	
National Science Foundation	2000-2005
<i>Understanding and Surviving Computation in the Wild</i>	\$871,478
S. Forrest (PI), D. Ackley (Co-PI)	
Defense Advanced Research Projects Agency	2000-2005
<i>Computation in the Wild: Moving Beyond the Metaphor</i>	\$1,100,000
S. Forrest (PI), D. Ackley (Co-PI)	
Office of Naval Research	2000
<i>Dynamics Days Conference</i>	\$18,600
S. Forrest, David Egolf (PIs)	
National Science Foundation	1999-2002
<i>Physics Graduate Student Fellowships at the Santa Fe Institute</i>	\$321,622
E. Jen (PI), D. Campbell, J. Crutchfield, and S. Forrest (Co-PIs)	
Department of Energy	2001-2003
<i>A Broad Program in the Sciences of Complexity</i>	\$606,000
Co-PI with E. Goldberg, E. Jen, and M. Feldman	
Office of Naval Research	1999-2003
<i>Emergent Computation</i>	\$420,072
S. Forrest (PI)	
Intel Corporation	1998-2004
<i>Biologically Inspired Approaches to Computer Security</i>	\$42,1393
S. Forrest (PI)	
National Science Foundation	1997-2000
<i>Computer Immunology</i>	\$292,350
S. Forrest (PI)	
IBM	1998
<i>Partnership Award</i>	\$20,000
S. Forrest (PI)	
Defense Advanced Research Projects Agency	1996-98
<i>Research on a Simple Definition of Normal Behavior for Unix Processes</i>	\$755,728
S. Forrest (PI)	
NSF Research Training Grant	1995-2000
<i>A BIO Research Training Group in Ecological Complexity</i>	\$562,500
J. H. Brown (PI), S. Forrest, B. T. Milne, J. Rasure, L. M. Simmons, and G. C. Stevens (co-PIs)	
Office of Naval Research	1995-98
<i>Research in Computational Immunology</i>	\$400,000

NSF Presidential Young Investigator Award <i>Computational Aspects of the Immune System</i>	1991-1996 \$500,000
Sandia National Laboratories <i>Genetic programming for automatic learning and image classification</i>	1995-1996 \$26,039
Santa Fe Institute <i>Graduate student support</i>	1991-1995 \$166,178
Alfred P. Sloan Foundation <i>Foundations of Genetic Algorithms</i> S. Forrest, M. Mitchell (co-PIs)	1992-1994 \$30,000
Sandia University Research Program (SURP) <i>Inappropriate Convergence in Genetic Algorithms</i>	1991-1993 \$60,000
Association of Western Universities (AWU) <i>Faculty Fellowship</i>	1991-1991 \$10,000
Los Alamos National Laboratory (CNLS) <i>Genetic Algorithms and Classifier System</i>	1990-1991 \$20,382
University of California <i>Institutional Collaborative Research (INCOR) grant</i>	1989-1993 \$42,000

Ph.D. Students Graduated

- Terry Jones (1995) *Evolutionary algorithms, fitness landscapes and search* Cambridge Univ. UK
- Ron Hightower (1996) *Computational aspects of antibody gene families* Self-employed
- Derek Smith (1997) *The cross-reactive immune response* (Nominated for ACM Best Dissertation award) Prof. of Zoology, Cambridge Univ. UK
- Mihaela Oprea Zavalon (1999) *Optimizing the antibody repertoire for pathogen recognition* Prof. of Bioinformatics, Univ. of Basel, Switzerland
- Steven Hofmeyr (1999) *An immunological model of distributed detection and its application to network security* Lawrence Berkeley Laboratory
- Wim Hordijk (1999) *Dynamics, emergent computation, and evolution in cellular automata* Self-employed
- Patrik D'haeseleer (2000) *Reconstructing gene networks from large scale gene expression data* Lawrence Livermore National Laboratory
- Anil Somayaji (2002) *Operating system stability and security through process homeostasis* Assoc. Prof. of Computer Science, Carleton University, Ottawa
- Dennis L. Chao (2004) *Modeling the cytotoxic T cell response* Fred Hutchinson Cancer Research Center
- Christina Warrender (2004) *Modeling intercellular interactions in the peripheral immune system* Sandia National Laboratory
- Gabriela Barrantes (2005) *Automated methods for creating diversity in computer systems* Prof. and Chair of Computer Science, Universidad de Costa Rica
- Hajime Inoue (2005) *Anomaly detection in dynamic execution environments* Principle Scientist, Architecture Technology Corporation
- Fernando Esponda (2006) *Protecting Data Privacy through Hard-to-Reverse Negative Databases* Assoc. Prof. Instituto Tecnológico Autónomo de México
- Kenneth Ingham (2007) *Anomaly Detection for HTTP Intrusion Detection: Algorithm Comparisons and the Effect of Generalization on Accuracy* Self-employed
- Robert Abbott (2007) *Automated tactics modeling: Techniques and Applications* (UNM Popejoy Best Dissertation Award), Principal Member of the Technical Staff, Sandia National Laboratory
- Todd Kaplan (2008) *Detecting community structure in financial markets* Indeed.com
- Eric Trias (2008) *Leveraging positive and negative representations of information* U.S.A.F.

- Josh Karlin (2009) *Distributed Internet security and measurement* Google
- George Bezerra (2012) *Energy Consumption in Networks on Chip: Efficiency and Scaling* TripAdvisor
- Michael Groat (2012) *Energy Conserving Privacy Enhancing Algorithms in Resource-Constrained Devices* City of Farmington, NM
- ThanhVu Nguyen (2014) *Automating Program Verification and Repair Using Invariant Analysis and Test-input Generation* Asst. Professor, Univ. Nebraska, Lincoln
- Eric Schulte (2014) *Neutral Networks of Real-World Programs and their Application to Automated Software Evolution* Grammatech
- Drew Levin (2016) *The environment constrains successful search strategies in natural distributed systems* Sandia National Labs.
- Benjamin J. Edwards (2016) *Evidence-based cybersecurity: data-driven and abstract models* IBM, Thomas J. Watson Research Center.

Postdoctoral Supervision

- Dipankar Dasgupta (Univ. of Memphis, TN), Andrew Kosoresow (deceased), Derek Smith (Cambridge Univ. UK), Carlo Maley (Univ. California San Francisco), Steven Hofmeyr (Lawrence Berkeley Lab.), Matt Glickman (Sandia National Labs.), Catherine Beauchemin (Ryerson Univ. CAN), Petter Holme (Royal Institute of Technology, Stockholm), Melanie Moses (Univ. of New Mexico), Hugh Mitchell (Pacific Northwest National Lab.), Terri Oda (Intel Corp.), David Mohr (Google), A. Espinoza (current), J. Daymude (current)

Publications and Patents (reverse chronological order)

Patents

M. Ahmadi, K. Leach, S. Forrest, R. Dougherty, and W. Weimer. systems and methods for reducing malware analysis overhead with coverings. U.S. Provisional Patent 63/196,900, June 2021.

L. Allen, S. Forrest, and A. S. Perelson. A method of detecting changes to a collection of digital signals. U.S. patent 5448668, Sept. 1995.

Books and Conference Proceedings

S. Forrest. *Proc. of the Fifth Intl. Conference on Genetic Algorithms*. Morgan Kaufmann, Los Altos, CA, 1993.

S. Forrest. *Parallelism in Classifier Systems*. Research Notes in Artificial Intelligence. Pitman Publishing and Morgan Kaufmann, London and Los Altos, CA, 1991. Revised version of Ph.D. dissertation.

S. Forrest, editor. *Emergent Computation*. MIT Press, Cambridge, MA, 1991. Also published as *Physica D* special issue Vol. 42, Nos. 1-3 (1990).

L. Booker, S. Forrest, M. Mitchell, and R. Riolo, editors. *Perspectives on Adaptation in Natural and Artificial Systems*. Oxford University Press, 2005.

Chapters of Books

S. Forrest. Privacy concerns that arise with the pandemic. In D. Krakauer and G. West, editors, *The Interplay of Thermodynamics and Computation in Both Natural and Artificial Systems*. SFI Press, 2021.

J. Lacomis, J. Dorn, W. Weimer, and S. Forrest. Automatically reducing energy consumption of software. In D. Wolpert, editor, *The Interplay of Thermodynamics and Computation in Both Natural and Artificial Systems*. SFI Press, 2019.

M. Moses and S. Forrest. Beyond biology. In R. M. Sibley, J. H. Brown, and A. Kodrik-Brown, editors, *Metabolic Ecology: A Scaling Approach*, chapter 24, pages 293–301. Wiley-Blackwell, 2012.

C. Le Goues, A. Nguyen-Tuong, H Chen, J. W. Davidson S. Forrest, J. D. Hiser, J. C. Knight, and M. Van Gundy. Moving target defenses in the Helix self-regenerative architecture. In S. Jajodia et al., editor, *Moving Target Defense II: Application of Game Theory and Adversarial Modeling*, pages 115–146, 2012.

K. Ingham and S. Forrest. Network firewalls. In V. Rao Vemuri and V. Sreeharirao, editors, *Enhancing Computer security with Smart Technology*, pages 9–35. CRC Press, 2005.

S. Forrest, J. Balthrop, M. Glickman, and D. Ackley. Computation in the wild. In E. Jen, editor, *Robust Design: A Repertoire of Biological, Ecological, and Engineering Case Studies*, pages 207–230. Oxford University Press, 2004. Reprinted in K. Park and W. Willinger Eds. *The Internet as a Large-Scale Complex System*, pp. 227-250. Oxford University Press (2005).

D. J. Smith, A. S. Lapedes, S. Forrest, J. C. deJong, A. D. M. E. Osterhaus, R. A. M. Fouchier, N. J. Cox, and A. S. Perelson. Modeling the effects of updating the influenza vaccine on the efficacy of repeated vaccination. In A. D. M. E. Osterhaus, N. Cox, and A. Hampson, editors, *Options for the control of influenza virus IV*, International Congress 1219, pages 655–660. Excerpta Medica, Amsterdam, 2001.

S. Forrest and S. A. Hofmeyr. Immunology as information processing. In L. A. Segel and I. Cohen, editors, *Design Principles for the Immune System and Other Distributed Autonomous Systems*, Santa Fe Institute Studies in the Sciences of Complexity. Oxford University Press, 2001.

J.H. Holland, L. B. Booker, M. Colombetti, M. Dorigo, S. Forrest, D. G. Goldberg, R. L. Riolo, R. E. Smith, P. L. Lanzi, W. Stolzmann, and S. W. Wilson. What is a learning classifier system? In P. L. Lanzi, W. Stolzmann, and S. W. Wilson, editors, *Learning Classifier Systems: An Introduction to Contemporary Research*, pages 3–32. Springer Verlag, 2000.

D. J. Smith, S. Forrest, and A. S. Perelson. Immunological memory is associative. In D. Dasgupta, editor, *Artificial Immune Systems and Their Applications*. Springer-Verlag, Berlin, 1998.

D. J. Smith, S. Forrest, D. H. Ackley, and A. S. Perelson. Modeling the effects of prior infection on vaccine efficacy. In D. Dasgupta, editor, *Artificial Immune Systems and Their Application*. Springer-Verlag, Berlin, 1998.

M. Mitchell and S. Forrest. Fitness landscapes: Royal road functions. In Back, Fogel, and Michalewicz, editors, *Handbook of Evolutionary Computation*, volume B2.7, pages 1–25. Institute of Physics Publishing, Philadelphia and Bristol UK, 1997.

R. Hightower, S. Forrest, and A. S. Perelson. The Baldwin effect in the immune system: Learning by somatic hypermutation. In R. K. Belew and M. Mitchell, editors, *Adaptive Individuals in Evolving Populations*, pages 159–167. Addison-Wesley, Reading, MA, 1996.

S. Forrest. Genetic algorithms. In A. B. Tucker, editor, *CRC Handbook of Computer Science and Engineering*. CRC Press, Boca Raton, 1996.

C. Burks, M. L. Engle, S. Forrest, R. J. Parsons, C. A. Soderlund, and P. E. Stolorz. Stochastic optimization tools for genomic sequence assembly. In J.C. Venter, editor, *Automated DNA Sequencing and Analysis Techniques*. Academic Press, London, 1993.

S. Forrest and G. Mayer-Kress. Genetic algorithms, nonlinear dynamical systems, and global stability models. In L. Davis, editor, *The Handbook of Genetic Algorithms*. Van Nostrand Reinhold, New York, 1991.

S. Forrest. Knowledge-based approaches for real-time process management. In M. G. Singh, editor, *Systems and Control Encyclopedia, First Supplement*. Pergamon Books, Oxford, 1990.

Refereed Journal Articles.....

J. Renzullo, W. Weimer, and S. Forrest. Evolving software: Combining online learning with mutation-based stochastic search. *ACM Transactions on Evolutionary Learning and Optimization (TELO)*, (Submitted, Feb. 2022).

- R. Axelrod, J. Daymude, and S. Forrest. Preventing extreme polarization of political attitudes. *Proc. of the Nat. Acad. of Science*, 118(50), Dec. 14, 2021.
- C. Buckner, R. Miikkulainen, S. Forrest, S. Milano, J. Zou, C. Prunk, C. Irrgang, C. Glenn, H. Su, R. Murphy, et al. AI reflections in 2021. *Nature Machine Intelligence*, pages 5–10, 2022.
- M. Moses, S. Hofmeyr, J. Cannon, A. Andrews, R. Gridley, M. Hinga, K. Leyba, A. Pribisova, V. Surdidijaja, H. Tasnim, and S. Forrest. Spatially distributed infection increases viral load in a computational model of SARS-CoV-2 lung infection. *PLoS Computational Biology*, 17(12), (2021).
- R. Miikkulainen and S. Forrest. A biological perspective on evolutionary computation. *Nature Machine Intelligence*, 3:1–7, 2021.
- C. Martinez, D. A. Najera-Flores, A. R. Brink, D. D. Quinn, E. Chatzi, and S. Forrest. Confronting domain shift in trained neural networks. *Proc. of Machine Learning Research (PMLR)*, 148:176–192, 2021.
- D. Jacobs, T. McDaniel, A. Varsani, R. Halden, S. Forrest, and H. Lee. Wastewater monitoring raises privacy and ethical considerations. *IEEE Trans. on Technology and Society*, 2(3), 2021.
- J. Liou, X. Wang, S. Forrest, and C. Wu. Post-compiler performance tuning for general-purpose GPU kernels. *ACM Trans. on Architecture and Code Optimization*, 17(4), 2020.
- J. Lehman, ..., S. Forrest, and 51 other authors. The surprising creativity of digital evolution: A collection of anecdotes from the evolutionary computation and artificial life research communities. *Artificial Life*, 26(2), (2020).
- W. Vining, F. Esponda, M. Moses, and S. Forrest. How does mobility help distributed systems compute? *Philosophical Trans. of the Royal Society B*, 374(1774), 2019.
- R. Sole, M. Moses, and S. Forrest. Liquid brains, solid brains. *Philosophical Trans. of the Royal Society B*, 374(1774), 2019. DOI 10.1098/rstb.2019.0040.
- M. E. Moses, J. L. Cannon, D. M. Gordon, and S. Forrest. Distributed adaptive search in t cells: Lessons from ants. *Frontiers Immunology*, 10:1357, 2019.
- J. Dorn, J. Lacomis, W. Weimer, and S. Forrest. Automatically exploring tradeoffs between software output fidelity and energy costs. *IEEE Trans. on Software Engineering*, 45:219–236, 2019. on-line version published Nov. 2017.
- C. Le Goues, Y. Brun, S. Forrest, and W. Weimer. Clarifications on the construction and use of the manybugs benchmark. *Trans. on Software Engineering*, 43(11):1089–1090, (2017). DOI 10.1109/TSE.2017.2755651.
- B. Edwards, A. Furnas, S. Forrest, and R. Axelrod. Strategic aspects of cyber attack, attribution, and blame. *Proc. Nat. Acad. Sci (PNAS)*, 114(11):2825–2830, 2017.
- M. Moses, G. Bezerra, B. Edwards, J. H. Brown, and S. Forrest. Energy and time determine scaling in biological and computer designs. *Phil. Trans. of the Royal Society B*, 371(1701), 2016.
- D. Levin, S. Forrest, S. Banerjee, C. Clay, J. Cannon, M. Moses, and F. Koster. A spatial model of the efficiency of T cell search in the influenza-infected lung. *J. Theoretical Biology*, 398:52–63, 2016. doi 10.1016/j.jtbi.2016.02.022.
- S. Forrest and M. Mitchell. Adaptive computation: The multidisciplinary legacy of John H. Holland. *Communications of the ACM*, 59(8):58–63, 2016. doi 10.1145/2964342.
- B. Edwards, S. Hofmeyr, and S. Forrest. Hype and heavy tails: Analyzing ten years of data breaches. *Journal of Cybersecurity*, 2(1):3–14, 2016. doi: 10.1093/cybsec/tyw003 (Updated and expanded revision of WEIS 2015 conference paper.).

- C. Le Goues, N. Holtschulte, E. Smith, Y. Brun, P. Devanbu, S. Forrest, and W. Weimer. The ManyBugs and IntroClass benchmarks for automated repair of C programs. *ACM Trans. on Software Engineering*, 41(12), 2015.
- E. Schulte, Z. P. Fry, E. Fast, W. Weimer, and S. Forrest. Software mutational robustness. *Genetic Programming and Evolvable Machines*, 15(3):281–312, 2014. DOI 10.1007/s10710-013-9195-.
- T. Nguyen, D. Kapur, W. Weimer, and S. Forrest. DIG: A dynamic invariant generator for polynomial and array invariants. *ACM Trans. on Software Engineering and Methodology*, 23(4), 2014. DOI 10.1145/2556782.
- M. Groat, B. Edwards, J. Horey, W. He, and S. Forrest. Application and analysis of multidimensional negative surveys in participatory sensing applications. *Pervasive and Mobile Computing*, 9(3):372–391, 2013.
- C. Le Goues, S. Forrest, and W. Weimer. Current challenges in automatic software repair. *Software Quality*, 21:421–443, 2013. DOI 10.1007/s11219-013-9208-0.
- C. Le Goues, T. Nguyen, S. Forrest, and W. Weimer. GenProg: A generic method for automatic software repair. *ACM Trans. on Software Engineering*, 38(1), 2012. Featured article award.
- H. Mitchell, D. Levin, S. Forrest, C. Beauchemin, J. Tipper, J. Knight, N. Donart, C. Layton, J. Pyles, P. Gao, K. Harrod, A. Perelson, and F. Koster. Higher replication efficiency of 2009 (H1N1) pandemic influenza than seasonal and avian strains: Kinetics from epithelial cell culture and computational modeling. *J. Virology*, 85(2):1125–1135, 2011. doi:10.1128/JVI.01722-10.
- W. Weimer, S. Forrest, C. Le Goues, and T. Nguyen. Automatic program repair with evolutionary computation. *Communications of the ACM*, 53(5):109–116, Research Highlight 2010.
- F. Esponda, S. Forrest, and P. Helman. Negative representations of information. *Intl. J. of Information Security*, 8(5), 2009. doi:10.1007/s10207-009-0078-1.
- M. Moses, S. Forrest, A. L. Davis M. Lodder, and J. H. Brown. Scaling theory for information networks. *Royal Society Interface*, 5(29):1391–1510, 2008.
- J. Karlin, J. Rexford, and S. Forrest. Autonomous security for autonomous systems. *Computer Networks*, 52:2908–2923, 2008.
- P. Holme, J. Karlin, and S. Forrest. An integrated model of traffic, geography and economy in the internet. *Computer Communication Review*, 38(3):7–15, 2008.
- K. Ingham, A. Somayaji, S. Forrest, and J. Burge. Learning dfa representations of http for protecting web applications. *Computer Networks*, 51(5):1239–1255, 2007.
- P. Holme, J. Karlin, and S. Forrest. Radial structure of the internet. *Proc. Royal Society A*, 463:1231–1246, 2007.
- S. Forrest and C. Beauchemin. Computer immunology. *Immunological Reviews*, 216:176–197, 2007.
- F. Esponda, E. S. Ackley, P. Helman, H. Jia, and S. Forrest. Protecting data privacy through hard-to-reverse negative databases. *Intl. J. of Information Security*, 6(6), 2007.
- C. Warrender, S. Forrest, and F. Koster. Modeling intercellular interactions in early mycobacterium infection. *Bulletin of Mathematical Biology*, 68(8):2233–61, 2006.
- H. Inoue, D. Stefanovic, and S. Forrest. On the prediction of Java object lifetimes. *IEEE Trans. on Computers*, 55(7):880–892, 2006.
- R. Gerety, S. Spencer, K. Pienta, and S. Forrest. Modeling somatic evolution in tumorigenesis. *PLoS Computational Biology*, 2(8), 2006.

- R. G. Abbott, S. Forrest, and K. J. Pienta. Simulating the hallmarks of cancer. *Artificial Life*, 12(4):617–634, 2006.
- M. Glickman, J. Balthrop, and S. Forrest. A machine learning evaluation of an artificial immune system. *Evolutionary Computation Journal*, 13(2):179–212, 2005.
- F. Esponda, E. S. Ackley, S. Forrest, and P. Helman. On-line negative databases. *J. of Unconventional Computing*, 1(3):201–220, 2005.
- D L. Chao, M. P. Davenport, S. Forrest, and A. S. Perelson. The effects of thymic selection on the range of T cell cross-reactivity. *European Journal of Immunology*, 35(3452-3459), 2005.
- G. Barrantes, D. Ackley, S. Forrest, and D. Stefanovic. Randomized instruction set emulation. *ACM Trans. on Information Systems Security (TISSEC)*, 8(1):3–40, 2005.
- C. Warrender, S. Forrest, and L. Segel. Homeostasis of peripheral immune effectors. *Bulletin of Mathematical Biology*, 66(6):1493–1514, 2004.
- C. C. Maley, B. J. Reid, and S. Forrest. Cancer prevention strategies that address the evolutionary dynamics of neoplastic cells: Simulating benign cell boosters and selection for chemosensitivity. *Cancer Epidemiology, Biomarkers and Prevention*, 13(8):1375–84, 2004.
- F. Esponda, S. Forrest, and P. Helman. A formal framework positive and negative detection. *IEEE Trans. on Systems, Man, and Cybernetics*, 34(1):357–373, 2004.
- D. L. Chao, M. P. Davenport, S. Forrest, and A. S. Perelson. A stochastic model of cytotoxic T cell responses. *J. Theoretical Biology*, 228:227–240, 2004.
- D. L. Chao, M. P. Davenport, S. Forrest, and A. S. Perelson. Modeling the impact of antigen kinetics on T cell activation and response. *Immunology and Cell Biology*, 82(1), 2004.
- J. Balthrop, S. Forrest, M. Newman, and M. Williamson. Technological networks and the spread of computer viruses. *Science*, 304:527–529, 2004.
- D. L. Chao and S. Forrest. Information immune systems. *Genetic Programming and Evolvable Machines*, 4(4):311–331, 2003.
- M. Newman, S. Forrest, and J. Balthrop. Email networks and the spread of computer viruses. *Physical Review E*, 66, 2002.
- M. Moses and S. Forrest. Book review of *The Computational Beauty of Nature* by G. Flake. *Artificial Intelligence*, 128:239–242, 2001.
- S. Forrest and S. Hofmeyr. Engineering an immune system. *Graft*, 4(5):5–9, 2001.
- C. C. Maley and S. Forrest. Exploring the relationship between neutral and selective mutations in cancer. *Artificial Life*, 6:325–345, 2000.
- S. Hofmeyr and S. Forrest. Architecture for an artificial immune system. *Evolutionary Computation*, 8(4):443–473, 2000.
- D. J. Smith, S. Forrest, D. H. Ackley, and A. S. Perelson. Variable efficacy of repeated annual influenza vaccination. *Proc. National Academy of Sciences*, 96:14001–14006, 1999.
- D. J. Smith, S. Forrest, D. H. Ackley, and A. S. Perelson. Using lazy evaluation to simulate realistic-size repertoires in models of the immune system. *Bulletin of Mathematical Biology*, 60:647–658, 1998.
- S. Hofmeyr, S. Forrest, and A. Somayaji. Intrusion detection using sequences of system calls. *J. of Computer Security*, 6:151–180, 1998.

- D. J. Smith, S. Forrest, R. R. Hightower, and A. S. Perelson. Deriving shape-space parameters from immunological data for a model of cross-reactive memory. *Theoretical Biology*, 189:141–150, 1997.
- P. Hraber, T. Jones, and S. Forrest. The ecology of Echo. *Artificial Life*, 3(3):165–190, 1997.
- S. Forrest, S. Hofmeyr, and A. Somayaji. Computer immunology. *Communications of the ACM*, 40(10):88–96, 1997.
- A. Perelson, R. Hightower, and S. Forrest. Evolution (and learning) of v-region genes. *Research in Immunology*, 147:202–208, 1996.
- S. Forrest. Genetic algorithms. *ACM Computing Surveys*, 28(1):77–80, 1996.
- R. Parsons, S. Forrest, , and C. Burks. Genetic operators for the DNA fragment assembly problem. *Machine Learning*, 21(1/2):11–33, 1995.
- M. Mitchell and S. Forrest. Genetic algorithms and artificial life. *Artificial Life*, 1994.
- R. E. Smith, S. Forrest, and A. S. Perelson. Searching for diverse, cooperative populations with genetic algorithms. *Evolutionary Computation*, 1(2):127–149, 1993.
- S. Forrest and M. Mitchell. What makes a problem hard for a genetic algorithm? Some anomalous results and their explanation. *Machine Learning*, 13(2/3):129–163, 1993.
- S. Forrest, B. Javornik, R. E. Smith, and A. S. Perelson. Using genetic algorithms to explore pattern recognition in the immune system. *Evolutionary Computation*, 1(3):191–211, 1993.
- S. Forrest. Genetic algorithms: principles of natural selection applied to computation. *Science*, 261:872–878, Aug. 1993.
- J. Lark, L. Erman, S. Forrest, K. Gostelow, F. Hayes-Roth, and D. Smith. Concepts, methods, and languages for building timely intelligent systems. *Real-time Systems*, 2(1), 1990.
- S. Forrest and J. H. Miller. Emergent behaviors of classifier systems. *Physica D*, 42(1–3):213–227, 1990.
- S. Forrest. Introduction to the proceedings of the ninth annual CNLS conference. *Physica D*, 42(1-3):1–11, 1990.
- R. Belew and S. Forrest. Learning and programming in classifier systems. *Machine Learning*, 3:193–223, 1988.
- B. D’Ambrosio, M. Fehling, S. Forrest, P. Raulefs, and M. Wilber. Real-time process management for materials composition in chemical manufacturing. *IEEE Expert*, pages 80–93, 1987.
- Refereed Conference Papers**
- P. Reiter, R. Wang, A. Doupe, W. Weimer, and S. Forrest. Automatically mitigating vulnerabilities in x86 binary programs via partially recompilable decompilation. In *25th International Symposium on Research in Attacks, Intrusions, and Defenses (RAID)*, Submitted, March 2022.
- J. Liou, M. Awan, S. Hofmeyr, C. Wu, and S. Forrest. Understanding the power of evolutionary computation for gpu code optimization. In *31st International Conference on Parallel Architectures and Compilation Techniques (PACT)*, Submitted, April 2022.
- H. Ahmad, P. Cashin, W. Weimer, and S. Forrest. Digging into semantics: Where do search-based software repair methods search? In *The Seventeenth International Conference on Parallel Problem Solving from Nature (PPSN XVII)*, Submitted, April 2022.
- K. Leyba, J. Daymude, J. Young, J. Rexford, M. Newman, and S. Forrest. Cutting through the noise to infer autonomous system topology. In *IEEE Conference on Computer Communications (INFOCOM 2022)*, in press (20% acceptance rate).

- A. Espinoza, S. Forrest, M. Tiwari, and R. Wood. Back to the future: N-versioning of microservices. In *International Conference on Dependable Systems and Networks (DSN)*, in press (18.7% acceptance rate).
- P. Reiter, A. Espinoza, R. Wang, A. Doupe, W. Weimer, and S. Forrest. Improving source-code representations to enhance search-based software repair. In *Genetic and Evolutionary Computation Conference (GECCO)*, in press.
- M. Endres, P. Reiter, S. Forrest, and W. Weimer. What can program repair learn from code review? In *ICSE International Workshop on Automated Program Repair*, in press.
- J. Renzullo, W. Weimer, and S. Forrest. Multiplicative weights algorithms for parallel automated software repair. In *35th IEEE International Parallel and Distributed Processing Symposium*, 2021.
- M. Ramamoorthy, S. Forrest, and V. Syrotiuk. MA-ABC: A memetic algorithm optimizing attractiveness, balance, and cost for capacitated arc routing problems. In *Genetic and Evolutionary Computation Conf. (GECCO)*, 2021.
- Y. Huang, Ahmad H, S. Forrest, and W. Weimer. Applying automated program repair to dataflow programming languages. In *ICSE 10th Intl. Workshop on Genetic Improvement*, 2021.
- Y. Qin, S. Gonzalez, K. Angstadt, X. Wang, S. Forrest, R. Das, K. Leach, and W. Weimer. Martini: Memory access traces to detect attacks. In *ACM Cloud Computing Security Workshop (CCSW'20)*, 2020.
- J. Liou, S. Forrest, and C. Wu. GEVO-ML: Optimizing machine learning codes with evolutionary computation. In *Genetic and Evolutionary Computation Conf. (GECCO) Workshop on NeuroEvolution at Work*, 2020.
- G. Stelle, D. Stefanovic, S., and S. Forrest. Cactus Environment Machine: Shared environment call-by-need. In *Post-proceedings of The 17th Symposium on Trends in Functional Programming*, 2019.
- J. Liou, S. Forrest, and C. Wu. Uncovering performance opportunities by relaxing program semantics of GPGPU kernels. In *ASPLOS, Wild and Crazy Ideas Session*, 2019. Extended abstract.
- J. Liou, S. Forrest, and C. Wu. Genetic improvement of GPU code. In *International Conf. on Software Engineering (ICSE) Genetic Improvement Workshop*, 2019. Best paper award.
- K. Leyba, B. Edwards, C. Freeman, J. Crandall, and S. Forrest. Borders and gateways: Measuring and analyzing national AS chokepoints. In *ACM Conf. on Computing and Sustainable Societies (COMPASS)*, 2019.
- K. Leach, R. Dougherty, C. Spensky, S. Forrest, and W. Weimer. Evolutionary computation for improving malware analysis. In *ICSE Genetic Improvement Workshop*, 2019. Extended abstract. Best presentation award.
- J. Jones, J. Hiser, J. Davidson, and S. Forrest. Defeating denial-of-service attacks in a self-managing N-variant system. In *14th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, 2019. Best paper award.
- R. E. Dougherty, E. Lanus, C. J. Colbourn, and S. Forrest. Genetic algorithms for affine transformations to existential t-restrictions. In *Genetic and Evolutionary Computation (GECCO) Workshop on Genetic Improvement*, 2019. Extended abstract.
- P. Cashin, W. Weimer, and S. Forrest. Understanding automatically-generated patches through symbolic invariant differences. In *34th IEEE/ACM Intl. Conf. on Automated Software Engineering (ASE)*, 2019.
- J. Renzullo, M. Moses, W. Weimer, and S. Forrest. Neutral networks enable distributed search in evolution. In *Genetic Improvement Workshop. International Conf. on Software Engineering (ICSE)*, 2018.

- T. Nguyen, W. Weimer, D. Kapur, and S. Forrest. Connecting program synthesis and reachability: Automatic program repair using test-input generation. In *International Conf. on Tools and Algorithms for the Construction and Analysis of Systems (TACAS)*, (2017).
- M. Moses, D. Levin, T. Flanagan, P. Finley, and S. Forrest. Disease surveillance: Design principles from immunology. In *Conf. on Complex Systems*, (2017).
- D. Levin, M. Moses, T. Flanagan, S. Forrest, and P. Finley. Negative selection based anomaly detector for multimodal health data. In *2017 IEEE Symposium on Artificial Life*, (2017).
- J. Ericksen, M. Moses, and S. Forrest. Automatically evolving a general controller for robot swarms. In *2017 IEEE Symposium on Artificial Life*, (2017).
- W. Weimer, S. Forrest, M. Kim, C. Le Goues, and P. Hurley. Trusted software repair for system resiliency. In *Proc. of the DSN*, 2016.
- M. Co, J. W. Davidson, J. D. Hiser, A. Nguyen-Tuong J. C. Knight, W. Weimer, J. Burket, G. L. Frazier, B. Dutertre T. M. Frazier, I. Mason, N. Shankar, and S. Forrest. Double Helix and RAVEN: A system for Cyber Fault Tolerance and Recovery. In *Proc. of the 11th Cyber and Information Security Research Conf. Oak Ridge National Laboratory*, 2016. Runner up, best paper.
- E. Schulte, W. Weimer, and S. Forrest. Repairing COTS router firmware without access to source code or test suites: A case study in evolutionary software repair. In *The First Intl. Genetic Improvement Workshop (GI)*, 2015. Best paper award.
- D. Levin, J. Hecker, M. Moses, and S. Forrest. Volatility and spatial distribution of resources determine ant foraging strategies. In *The 13th European Conf. on Artificial Life (ECAL)*, 2015.
- B. Edwards, S. Hofmeyr, S. Forrest, and M. van Eeten. Analyzing and modeling longitudinal security data: Promise and pitfalls. In *Proc. of the 31st Annual Computer Security Applications Conf. (ACSAC)*, pages 391–400. ACM, 2015.
- B. Edwards, S. Hofmeyr, and S. Forrest. Hype and heavy tails: A closer look at data breaches. In *Workshop on the Economics of Information Security*, June 2015. Best paper award.
- E. Schulte, J. Dorn, S. Forrest, and W. Weimer. Post-compiler software optimization for reducing energy. In *Nineteenth Intl. Conf. on Architectural Support for Programming Languages and Operating Systems (ASPLOS)*, 2014.
- T. Nguyen, D. Kapur, W. Weimer, and S. Forrest. Using dynamic analysis to generate disjunctive invariants. In *Intl. Conf. on Software Engineering*, 2014.
- S. Goldberg and S. Forrest. Implications of security enhancements and interventions for core Internet infrastructure. In *42nd Research Conf. on Communication, Information and Internet Policy (TPRC, 2014)*, 2014.
- W. Weimer, Z. Fry, and S. Forrest. Leveraging program equivalence for adaptive program repair: Models and first results. In *Automated Software Engineering (ASE) Conf.*, 2013.
- E. Schulte, J. DiLorenzo, W. Weimer, and S. Forrest. Automated repair of binary and assembly programs for cooperating embedded devices. In *Proc. of the Eighteenth Intl. Conf. on Architectural Support for Programming Languages and Operating Systems (ASPLOS)*, 2013.
- G. Bezerra and S. Forrest. Empirical and theoretical lower bounds on energy consumption for networks on chip. In *Workshop on Network on Chip Architectures (NoCArc)*, 2013.
- T. Nguyen, D. Kapur, W. Weimer, and S. Forrest. Using dynamic analysis to discover polynomial and array invariants. In *ICSE '12: Proc. of the IEEE 34th Intl. Conf. on Software Engineering*, Washington, DC, USA, 2012. IEEE Computer Society. SIGSOFT Distinguished Paper Award.

- J. Horey, M. Groat, and S. Forrest. Reconstructing spatial distributions from anonymized locations. In *Workshop on Secure Data Management Engineering (ICDE)*, 2012.
- M. Groat, B. Edwards, J. Horey, W. He, and S. Forrest. Enhancing privacy in participatory sensing applications with multidimensional data. In *2012 IEEE Intl. Conf. on Pervasive Computing and Communications (PerCom)*, pages 144–152. IEEE, 2012.
- C. Le Goues, W. Weimer, and S. Forrest. Representations and operators for improving evolutionary software repair. In *Genetic and Evolutionary Computation Conf. (GECCO)*, 2012. Nominated for best paper.
- C. Le Goues, M. Dewey-Vogt, S. Forrest, and W. Weimer. A systematic study of automated program repair: Fixing 55 out of 105 bugs for \$8.00 each. In *ICSE '12: Proc. of the IEEE 34th Intl. Conf. on Software Engineering*, Washington, DC, USA, 2012. IEEE Computer Society.
- B. Edwards, T. Moore, G. Stelle, S. Hofmeyr, and S. Forrest. Beyond the blacklist: Modeling malware spread and the effect of interventions. In *Proc. of the 2012 Workshop on New security paradigms*, pages 53–66. ACM, 2012.
- S. Hofmeyr, T. Moore, S. Forrest, B. Edwards, and G. Stelle. Modeling internet-scale policies for cleaning up malware. In *Workshop on the Economics of Information Security and Privacy (WEIS)*, pages 149–170. Springer, 2011.
- M. Groat, W. He, and S. Forrest. Kipda: k -indistinguishable privacy-preserving data aggregation in wireless sensor networks. In *INFOCOM*, 2011.
- G. Bezerra, S. Forrest, and P. Zarkesh-Ha. Reducing energy and increasing performance with traffic optimization in any-core systems. In *ACM/IEEE Intl. Workshop on System Level Interconnect Prediction (SLIP)*, New York, NY, 2011. ACM.
- S. Banerjee, D. Levin, M. Moses, F. Koster, and S. Forrest. The value of inflammatory signals in adaptive immune responses. In P. Li, G. Nicosia, and T. Stibor, editors, *Intl. Conf. on Artificial Immune Systems (ICARIS)*, 2011.
- P. Zarkesh-Ha, G. Bezerra, S. Forrest, and M. Moses. Hybrid network on chip (hnoc): Local buses with a global mesh architecture. In *ACM/IEEE Intl. Workshop on System Level Interconnect Prediction (SLIP)*, Anaheim, CA, 2010. ACM.
- E. Schulte, S. Forrest, and W. Weimer. Automated program repair through the evolution of assembly code. In *25nd IEEE/ACM Intl. Conf. on Automated Software Engineering*, pages 313–16, 2010.
- C. Le Goues, S. Forrest, and W. Weimer. The case for software evolution. In *FSE/SDP Workshop on the Future of Software Engineering Research*, 2010.
- E. Fast, C. Le Goues, W. Weimer, and S. Forrest. Designing better fitness functions for automated program repair. In *Proc. of the 12th Genetic and Evolutionary Computation Conf. (GECCO)*, 2010.
- G. Bezerra, S. Forrest, M. Moses, A. Davis, and P. Zarkesh-H. Communication probability distribution and energy consumption in networks on chip. In *ACM/IEEE Intl. Workshop on System Level Interconnect Prediction (SLIP)*, Anaheim, CA, 2010. ACM.
- W. Weimer, T. Nguyen, C. Le Goues, and S. Forrest. Automatically finding patches using genetic programming. In *ICSE '09: Proc. of the 2009 IEEE 31st Intl. Conf. on Software Engineering*, pages 364–374, Washington, DC, USA, 2009. IEEE Computer Society. 2019 ICSE Most Influential Paper Award (for papers published at ICSE in 2009). SIGSOFT Distinguished Paper Award.
- S. Forrest, T. Nguyen, W. Weimer, and C. Le Goues. A genetic programming approach to automated software repair. In *GECCO '09: Proc. of the 11th Annual Conf. on Genetic and Evolutionary Computation*, pages 947–954, New York, NY, USA, 2009. ACM. Best paper award.

- E. Trias, J. Navas, E. Ackley, S. Forrest, and M. Hermenegildo. Two efficient representations for set-sharing analysis in logic programs. In *Proc. of the 17th Intl. Workshop on Functional and (Constraint) Logic Programming*, Electronic Notes in Theoretical Computer Science. www.elsevier.nl/locate/entcs, 2008.
- E. Trias, J. Navas, E. Ackley, S. Forrest, and M. Hermenegildo. Negative ternary set sharing. In *Proc. of the Intl. Conf. on Logic Programming (ILCP)*, volume 5366 of *Lecture Notes in Computer Science*, pages 301–316, Berlin / Heidelberg, 2008. Springer.
- S. Forrest, S. Hofmeyr, and A. Somayaji. The evolution of system-call monitoring. In *ACSAC '08: Procc. of the 2008 Annual Computer Security Applications Conf.*, pages 418–430, Washington, DC, USA, 2008. IEEE Computer Society. Invited paper for Classic Papers session.
- J. R. Crandall, R. Ensafi, S. Forrest, J. Ladau, and B. Shebaro. The ecology of malware. In *Proc. of the New Security Paradigms Workshop (NSPW)*, 2008.
- J. Horey, M. Groat, S. Forrest, and F. Esponda. Anonymous data collection in sensor networks. In *The 4th Annual Intl. Conf. on Mobile and Ubiquitous Systems: Computing, Networking and Services (MOBIQUITOUS)*, 2007.
- J. Karlin, J. Rexford, and S. Forrest. Pretty Good BGP: Improving BGP by cautiously adopting routes. In *Intl. Conf. on Network Protocols (ICNP)*, 2006.
- F. Esponda, H. Jia, S. Forrest, and P. Helman. Protecting data privacy through hard-to-reverse negative databases. In *Proc. of the Information Security Conf. (ISC06)*, Lecture Notes in Computer Science, Berlin, 2006. Springer.
- C. Beauchemin, S. Forrest, and F. Koster. Modeling influenza viral dynamics in tissue. In *Proc. of the 5th Intl. Conf. on Artificial Immune Systems (ICARIS)*, volume 4163 of *Lecture Notes In Computer Science*, pages 23–36, Berlin, 2006. Springer.
- E. G. Barrantes and S. Forrest. Increasing communications security through protocol parameter diversity. In *Proc. of the XXXII Latin-American Conf. on Informatics (CLEI 2006)*, Santiago, CHILE, 2006.
- H. Inoue and S. Forrest. Inferring Java security policies through dynamic sandboxing. In *Intl. Conf. on Programming Languages and Compilers (PLC'05)*, 2005.
- D. L. Chao, J. Balthrop, and S. Forrest. Adaptive Radio: Achieving consensus using negative preferences. In *ACM Group*, 2005.
- F. Esponda, E. Ackley, S. Forrest, and P. Helman. On-line negative databases. In *Third Intl. Conf. on Artificial Immune Systems (ICARIS)*, 2004. Best paper award.
- F. Esponda, S. Forrest, and P. Helman. The crossover closure and partial match detection. In *The second Intl. Conf. on Artificial Immune Systems (ICARIS)*, number 2787 in *Lecture Notes in Computer Science*, Berlin, 2003. Springer-Verlag. Best paper award.
- D. L. Chao and S. Forrest. Generating biomorphs with an aesthetic immune system. In *Artificial Life VIII: The 8th Intl. Conf. on the Simulation and Synthesis of Living Systems*, pages 89–92, Cambridge, MA, 2003. The MIT Press.
- D. L. Chao, M. Davenport, S. Forrest, and A. Perelson. Stochastic stage-structured modeling of the adaptive immune system. In *IEEE Computer Society Bioinformatics Conf. (CSB2003)*, 2003.
- G. Barrantes, D. Ackley, S. Forrest, T. Palmer, D. Stefnaovic, and D. Zovi. Randomized instruction set emulation to disrupt binary code injection attacks. In *10th ACM Conf. on Computer and Communications Security*, 2003.
- H. Inoue and S. Forrest. Anomaly intrusion detection in dynamic execution environments. In *Proc. of the New Security Paradigms Workshop*, pages 52–60, Danvers, MA, 2002. ACM Press.

- D. L. Chao and S. Forrest. Information immune systems. In *Intl. Conf. on Artificial Immune Systems (ICARIS)*, pages 132–140, UK, 2002. University of Kent at Canterbury.
- J. Balthrop, S. Forrest, and M. Glickman. Revisiting LISYS: Parameters and normal behavior. In *Congress on Evolutionary Computation (CEC)*, 2002.
- J. Balthrop, F. Esponda, S. Forrest, and M. Glickman. Coverage and generalization in an artificial immune system. In W. B. Langdon et al., editor, *Proc. of the Genetic and Evolutionary Computation Conf. (GECCO)*, pages 3–10, New York, 2002. Morgan Kaufman.
- C. Warrender, S. Forrest, and L. Segel. Effective feedback in the immune system. In *Evolutionary Evolutionary Computation and Multi-Agent Systems (ECOMAS) workshop, GECCO*, San Francisco, CA, 2001.
- A. Somayaji and S. Forrest. Automated response using system-call delays. In *Usenix*, 2000.
- C. Maley and S. Forrest. Modeling the role of neutral and selective mutations in cancer. In *Seventh Artificial Life Conf.*, 2000.
- C. Warrender, S. Forrest, and B. Pearlmutter. Detecting intrusions using system calls: Alternative data models. In *IEEE Symposium on Security and Privacy*, pages 133–145. IEEE Computer Society, 1999.
- M. Oprea and S. Forrest. How the immune system generates diversity: Pathogen space coverage with random and evolved antibody libraries. In *Proc. of the Genetic and Evolutionary Computation Conf. (GECCO)*, pages 1651–1656. Morgan-Kaufmann, 1999.
- S. Hofmeyr and S. Forrest. Immunity by design: An artificial immune system. In *Proc. of the Genetic and Evolutionary Computation Conf. (GECCO)*, pages 1289–1296. Morgan-Kaufmann, 1999. Impact Award for the highest impact paper published at GECCO 2009.
- D. Dasgupta and S. Forrest. Artificial immune systems in industrial applications. In *Intl. Conf. on Intelligent Processing and Manufacturing Material (IPMM)*, Honolulu, HI, 1999.
- M. Oprea and S. Forrest. Simulated evolution of antibody gene libraries under pathogen selection. In *IEEE Intl. Conf. on Systems, Man, and Cybernetics*, 1998.
- A. Somayaji, S. Hofmeyr, and S. Forrest. Principles of a computer immune system. In *New Security Paradigms Workshop*, 1997.
- S. Forrest, A. Somayaji, and D. H. Ackley. Building diverse computer systems. In *Sixth Workshop on Hot Topics in Operating Systems (HotOS)*, pages 67–72, Los Alamitos, CA, 1997. IEEE Computer Society Press.
- S. Forrest, S. A. Hofmeyr, A. Somayaji, and T. A. Longstaff. A sense of self for unix processes. In *IEEE Symposium on Computer Security and Privacy*, pages 120–128. IEEE Computer Society Press, 1996.
- P. D’haeseleer, S. Forrest, and P. Helman. An immunological approach to change detection: algorithms, analysis, and implications. In *IEEE Symposium on Computer Security and Privacy*, pages 110–119. IEEE Computer Society Press, 1996.
- D. Dasgupta and S. Forrest. Novelty detection in time series data using ideas from immunology. In *Intl. Conf. on Intelligent Systems*, 1996. Best paper award.
- T. Jones and S. Forrest. Fitness distance correlation as a measure of problem difficulty for genetic algorithms. In L. J. Eshelman, editor, *Sixth Intl. Conf. on Genetic Algorithms*, pages 184–192. Morgan Kaufmann, 1995.
- R. Hightower, S. Forrest, and A. S. Perelson. The evolution of emergent organization in immune system gene libraries. In L. J. Eshelman, editor, *Sixth Intl. Conf. on Genetic Algorithms*, pages 344–350. Morgan Kaufmann, 1995.

- M. Mitchell, J. H. Holland, and S. Forrest. When will a genetic algorithm outperform hill climbing? In J. D. Cowan, G. Tesauro and J. Alspector, editors, *Advances in Neural Information Processing Systems (NIPS)* 6. Morgan Kaufmann, 1994.
- S. Forrest, A. S. Perelson, L. Allen, and R. Cherukuri. Self-nonsel self discrimination in a computer. In *IEEE Symposium on Research in Security and Privacy*, pages 202–212. IEEE Computer Society Press, 1994.
- S. Forrest and T. Jones. Modeling complex adaptive systems with Echo. In R.J. Stonier and X.H. Yu, editors, *Complex Systems: Mechanism of Adaptation*, pages 3–21, Amsterdam, 1994. IOS Press.
- R. Smith, S. Forrest, and A. S. Perelson. An immune system model for maintaining diversity in a genetic algorithm. In L. D. Whitley, editor, *Proc. of a Workshop on Foundations of Genetic Algorithms (FOGA)*. Morgan Kaufmann, 1993.
- R. Parsons, S. Forrest, and C. Burks. Genetic algorithms for dna sequence assembly. In et al. L. Hunter, editor, *First Intl. Conf. on Intelligent Systems for Molecular Biology*. AAAI/MIT Press, 1993.
- S. Forrest and M. Mitchell. Towards a stronger building-blocks hypothesis: effects of relative building-block fitness on ga performance. In L. D. Whitley, editor, *Workshop on Foundations of Genetic Algorithms (FOGA)*. Morgan Kaufmann, 1993.
- W.E. Schmitendorf, O. Shaw, R. Benson, and S. Forrest. Using genetic algorithms for controller design: Simultaneous stabilization and eigenvalue placement in a region. In *AIAA Guidance Navigation and Control Conf.*, Hilton Head, SC, 1992.
- M. Mitchell, S. Forrest, and J. Holland. The royal road for genetic algorithms: fitness landscapes and ga performance. In *Proc. of the First European Conf. on Artificial Life (ECAL)*. MIT Press, 1992.
- T. M. Murdock, W. E. Schmitendorf, and S. Forrest. Use of a genetic algorithm to analyze robust stability problems. In *Proc. of the American Automatic Control Conf.*, Boston, 1991.
- S. Forrest and A. S. Perelson. Genetic algorithms and the immune system. In H. Schwefel and R. Maenner, editors, *Parallel Problem Solving from Nature (PPSN)*, Lecture Notes in Computer Science, Berlin, 1991. Springer-Verlag.
- S. Forrest and M. Mitchell. The performance of genetic algorithms on walsh polynomials: Some anomalous results and their explanation. In *Fourth Intl. Conf. on Genetic Algorithms (ICGA)*, 1991.
- J. H. Miller and S. Forrest. A dynamical systems approach to classifier systems. In J. Grefenstette, editor, *Proc. of the Third Intl. Conf. on Genetic Algorithms (ICGA)*. Morgan Kaufmann, 1989.
- S. Forrest. Modeling high-level symbolic structures in parallel systems that support learning. In M. Elzas, T. Oren, and B. Zeigler, editors, *Modelling and Simulation Methodology: Knowledge Systems Paradigms*. North Holland, 1989. Presented at the 1987 4th Intl. Symposium on Modeling and Simulation Methodology.
- S. Forrest. The classifier system: a computational model that supports machine intelligence. In *IEEE Intl. Conf. on Parallel Processing (ICPP)*, 1986.
- S. Forrest. Implementing semantic network structures using the classifier system. In J. Grefenstette, editor, *Intl. Conf. on Genetic Algorithms and Their Applications (ICGA)*, 1985.
- L. Erman, M. Fehling, S. Forrest, and J. Lark. Abe: architectural overview. In *Proc. of the Workshop on Distributed Artificial Intelligence*, 1985.