Stephanie Forrest

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Education

University of Michigan — **Ann Arbor,MI**
Ph.D. Computer and Communication Sciences — *1985*

University of Michigan — **Ann Arbor,MI**
M.S. Computer and Communication Sciences — *1982*

St. John's College — **Annapolis, MD and Santa Fe, NM**
B.A. (Liberal Arts, no major offered) — *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 — **Tempe, AZ**
2017–present
- Director, Biodesign Center for Biocomputation, Security and Society, 2017–present
- Professor of Computer Science, 2017–present

University of New Mexico — **Albuquerque, NM**
Dept. of Computer Science — *1990–2017*
- 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

Santa Fe Institute — **Santa Fe, NM**
- Research Professor, part-time sabbatical leave, 2003–2006
- Interim Vice President for Academic Affairs, 1999–2000

Massachusetts Institute of Technology — **Cambridge, MA**
Visiting Assoc. Professor (sabbatical leave) — *1996–1997*

Center for Nonlinear Studies, Los Alamos Nat. Laboratory — **Los Alamos, NM**
Director's Postdoctoral Fellow — *1988–1990*

Teknowledge, Inc. — **Palo Alto, CA**
Scientist and Senior Scientist — *1985–1988*

Honors and Awards

Test of Time Award
IEEE Security and Privacy Symposium *2020*
A sense of self for Unix system calls published in 1996

Most Influential Paper Award
ACM/SIGSOFT and IEEE/TCSE *2019*
Most influential paper published at the 2009 Int. Conf. on Software Engineering (ICSE)

Impact Award
ACM/SIGEVO *2019*
Highest impact paper published at the 2009 Conf. on Genetic and Evolutionary Computation (GECCO)

IEEE Fellow *2015–present*

Stanislaw Ulam Lectures
Santa Fe Institute *2013*
- *Software engineering: Evolving computer programs*
- *Immunology: The complex science of cyberdefense*
- *Modeling computer networks from chips to the Internet*

Jefferson Science Fellowship
National Academies of Science and Engineering *2013–2014*

Allen Newell Award
Association for Computing Machinery and AAAI *2012*

University of New Mexico
- *UNM 57th Annual Research Lecture* (2012)
- *College of Engineering, Outstanding Research Award, Senior Faculty* (2000)
- *General Library Faculty Acknowledgment Award* (1999)
- *Regents Lecturer* (1994-97)
- *College of Engineering, Outstanding Research Award Junior Faculty* (1993)

Women in Technology Award
New Mexico Council on Technology *2009*

SIGEVO GECCO Impact Award
Association for Computing machinery *2009*
Highest impact paper published in the 1999 Genetic and Evolutionary Computation Conference

Humies $5000 Gold Medal Award
For human-competitive results produced by genetic and evolutionary computation *2009*

Manfred Paul Award for Excellence in Software: Theory and Practice
IFIP TC2 *2009*

Senior Fellow
International Society for Genetic and Evolutionary Computation *2003*

St. John's College
Alumni Award of Merit *2002*

National Science Fundation
Presidential Young Investigator Award *1991–1996*

Association of Western Universities Faculty Fellowship
Faculty Fellowship *1991*

Young Faculty Award
GE Foundation *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

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
- 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 **SubmittedApril 2022**
Machine Learning Inspired Single Molecule Biomarker Detection *$1,495,000 (ASU share: $475,000)*
M.P. Anantram (PI), S. Forrest, J. Hihath, and A. K. Das (co-PIs)

National Institutes of Health **Submitted Feb. 2022**
SIMCoV: A spatially explicit model to predict SARS-CoV-2 lung infection *$3,379,832 (ASU share: $775,016)*
M. Moses (PI), S. Forrest, J. Cannon, S. Bradfute (co-PIs)

National Science Foundations **Submitted Dec. 2021**
Near-Hardware Program Repair and Optimization *$1,200,000 (ASU share: $550,00)*
W. Weimer (PI), S. Forrest and K. Angstadt (co-PIs)

DARPA **Submitted Nov. 2021**
Euryale: Combating Emergent Execution with a GLANCE *$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**
Protecting at-risk populations from surveillance, censorship and targeted attacks *$246,078*
J. Crandall (PI), S. Forrest (co-PI)

Office of Naval Research **2021-2022**
GPU servers for computational biomaterial design, evolutionary GPU code *$121,831*
P. Sulc (PI), S. Forrest (co-PI)

National Science Foundation **2021-2024**
CICI:UCSS:Securing Data for Wastewater-based Epidemiology *$499,592*
S. Forrest (PI), R. Halden, H. Lee, N. Trieu (co-PIs)

National Science Foundation **2020-2021**
RAPID: Spatial Modeling of Imm. Response to SARS-Cov-2 Infection *$200,000 (ASU share: $79,864)*
M. Moses (PI), S. Forrest (co-PI)

DARPA **2020-2024**
VOLT: A Viscous, Orchestrated Lifting and Translation Framework *$7,980,452*
R. Wang(PI), S. Forrest and 5 others (co-PIs)

National Science Foundation **2019-2022**
SHF: Understanding and Evolving Search-based Software Imprvmt. *$500,000 (ASU share: $250,00)*
S. Forrest (PI), W. Weimer (co-PI)

Defense Advanced Research Projects Agency **2019-2022**
CHECRS: Cognitive Human Enhancements for Cyber Reasoning Systems *$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**
Improving search-based and semantic automated prog. repair$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**
Trusted and resilient mission operation *$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**
ADVANCE at UNM: Institute for Diversity and Equity Across STEM (IDEAS) *$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**
Applying Bio. Imm. Sys. Concepts to Improve Electronic Biosurveillance Sys. Performance *$50,000*
S. Forrest (PI)

National Science Foundation **2016-2017**
CS 10K: New Mexico Computer Science for All (NM CSforAll) *$169,407*
(Subaward from Santa Fe Institute)

National Science Foundation **2015-2018**
NeTS: Large: Measuring and Modeling Internet Choke Points as Threats to Online Freedom *$1,400,000*
J. Crandall (PI), M. Faloutsos, S. Forrest (Co-PIs)

Defense Advanced Research Projects Agency **2015-2018**
Double Helix: High-Assurance N-Variant Systems *$5,330,000 (UNM/ASU share: $812,866)*
J. Davidson (PI), S. Forrest, B. Dutertre (Co-PIs)

Air Force Research Laboratory **2015-2017**
Cooperative, Trusted Software Repair for Cyber Physical System Resiliency *$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**
SHF: 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**
Reconstructing Information from Database Fragments Via Negative Partial Match Detection *$100,000*
S. Forrest (PI), P. Helman (Co-PI)

National Science Foundation **2003-2007**
Automated and Adaptive Diversity for Improving Computer Sys. Sec. *$1,200,000, UNM Share: $250,000*

D. Song (PI), M. Reiter, S. Forrest (Co-PIs)

Defense Advanced Research Projects Agency **2002-2003**
Automated Diversity in Computer Systems UNM Component *$280,000*
S. Forrest (PI)

National Institutes of Health **2002-2005**
P20 Center for the Spatiotemporal Modeling of Cell Signaling Planning Grant *$988,815*
J. Oliver (PI), S. Steinberg, S. Forrest, and G. Heffelfinger (Co-PIs)

Intel Corp. **2001-2003**
Information Immune Systems *$154,000*
S. Forrest, PI

National Science Foundation **2000-2005**
Understanding and Surviving Computation in the Wild *$871,478*
S. Forrest (PI), D. Ackley (Co-PI)

Defense Advanced Research Projects Agency **2000-2005**
Computation in the Wild: Moving Beyond the Metaphor *$1,100,000*
S. Forrest (PI), D. Ackley (Co-PI)

Office of Naval Research **2000**
Dynamics Days Conference *$18,600*
S. Forrest, David Egolf (PIs)

National Science Foundation **1999-2002**
Physics Graduate Student Fellowships at the Santa Fe Institute *$321,622*
E. Jen (PI), D. Campbell, J. Crutchfield, and S. Forrest (Co-PIs)

Department of Energy **2001-2003**
A Broad Program in the Sciences of Complexity *$606,000*
Co-PI with E. Goldberg, E. Jen, and M. Feldman

Office of Naval Research **1999-2003**
Emergent Computation *$420,072*
S. Forrest (PI)

Intel Corporation **1998-2004**
Biologically Inspired Approaches to Computer Security *$42,1393*
S. Forrest (PI)

National Science Foundation **1997-2000**
Computer Immunology *$292,350*
S. Forrest (PI)

IBM **1998**
Partnership Award *$20,000*
S. Forrest (PI)

Defense Advanced Research Projects Agency **1996-98**
Research on a Simple Definition of Normal Behavior for Unix Processes *$755,728*
S. Forrest (PI)

NSF Research Training Grant **1995-2000**
A BIO Research Training Group in Ecological Complexity *$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**
Research in Computational Immunology *$400,000*

NSF Presidential Young Investigator Award **1991-1996**
Computational Aspects of the Immune System *$500,000*

Sandia National Laboratories **1995-1996**
Genetic programming for automatic learning and image classification *$26,039*

Santa Fe Institute **1991-1995**
Graduate student support *$166,178*

Alfred P. Sloan Foundation **1992-1994**
Foundations of Genetic Algorithms *$30,00*
S. Forrest, M. Mitchell (co-PIs)

Sandia University Research Program (SURP) **1991-1993**
Inappropriate Convergence in Genetic Algorithms *$60,000*

Association of Western Universities (AWU) **1991-1991**
Faculty Fellowship *$10,000*

Los Alamos National Laboratory (CNLS **1990-1991**
Genetic Algorithms and Classifier System *$20,382*

University of California **1989-1993**
Institutional Collaborative Research (INCOR) grant *$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 Tecnologico Autonomo de Mexico
- 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. ystems 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-Blackwel, 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. Murphyemac, 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.

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