

Stephanie Forrest

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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

CICI:UCSS:Securing Data for Wastewater-based Epidemiology

S. Forrest (PI), R. Halden, H. Lee, N. Trieu (co-PIs)

Submitted Jan. 2021

\$499,592

U.S. Dept. of State

Protecting at-risk populations from surveillance, censorship, and targeted attacks

Submitted March 2020

\$1,295,512

J. Crandall (PI), S. Forrest (co-PI)

National Science Foundation **Submitted Feb. 2020**
BII Implementation: Failure and Regeneration in Complex Biological Systems at Scale \$12,488,140
M. Laubichler (PI), M. Angilletta, K. Buetow, S. Forrest, J. Maienschein (co-PIs)

National Science Foundation **2020-2021**
RAPID: Spatial Modeling of Imm. Response to SARS-Cov-2 Infection \$200,00 (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 **2019-2021**
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
<i>ASIM: An integrated agent-based model of a complex network</i>	UNM share: \$600,000
S. Hofmeyr (PI), S. Forrest (Co-PI)	
National Science Foundation	2009-2012
<i>SHF: Medium: Collab. Res.: Fixing real bugs in real programs using evolutionary algorithms</i>	\$600,000
W. Weimer (PI), S. Forrest (Co-PI)	
National Science Foundation	2007-2008
<i>Safe Computing Workshop: Introspective Hardware Architectures for Information Assurance</i>	\$69,930
S. Forrest (PI)	
Air Force Office of Scientific Research MURI	2007-2012
<i>Helix: A Self-Regenerative Architecture for the Incorruptible Enterprise</i>	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
<i>Modeling Early Influenza Virus Replication in Primary Human Lung Cells</i>	UNM Share: \$144,046
F. Koster (PI), S. Forrest (Co-PI)	
National Science Foundation	2006-2009
<i>Collaborative Research: A Biologically Motivated Scaling Theory for Computing</i>	\$230,921
S. Forrest (PI), J. Brown, A. Davis (Co-PIs)	
Howard Hughes Medical Institute	2006-2011
<i>Program in Interdisciplinary Biomedical Science (PIBS)</i>	\$1,000,000
J. Brown (PI), S. Forrest, N. Kenkre and F. Smith (Co-PIs).	
Motorola	2005-2008
<i>Biological Design for Computer Security</i>	\$150,000
S. Forrest (PI)	
SFI International Program	2005-2006
<i>Instruction Set Diversification</i>	\$17,500
G. Barrantes, J. Vargas, and S. Forrest (PIs)	
UNM/LANL Joint Science and Technology Laboratory	2005-2007
<i>Realistic Modeling of the Immune Response in Tissue</i>	\$131,750
S. Forrest and A. S. Perelson (PIs)	
National Institutes of Health	2003-2008
<i>COBRE Center for Evolutionary and Theoretical Immunology</i>	\$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
<i>Sensitive Information in a Wired World</i>	\$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. <i>Information Immune Systems</i> S. Forrest, PI	2001-2003 \$154,000
National Science Foundation <i>Understanding and Surviving Computation in the Wild</i> S. Forrest (PI), D. Ackley (Co-PI)	2000-2005 \$871,478
Defense Advanced Research Projects Agency <i>Computation in the Wild: Moving Beyond the Metaphor</i> S. Forrest (PI), D. Ackley (Co-PI)	2000-2005 \$1,100,000
Office of Naval Research <i>Dynamics Days Conference</i> S. Forrest, David Egolf (PIs)	2000 \$18,600
National Science Foundation <i>Physics Graduate Student Fellowships at the Santa Fe Institute</i> E. Jen (PI), D. Campbell, J. Crutchfield, and S. Forrest (Co-PIs)	1999-2002 \$321,622
Department of Energy <i>A Broad Program in the Sciences of Complexity</i> Co-PI with E. Goldberg, E. Jen, and M. Feldman	2001-2003 \$606,000
Office of Naval Research <i>Emergent Computation</i> S. Forrest (PI)	1999-2003 \$420,072
Intel Corporation <i>Biologically Inspired Approaches to Computer Security</i> S. Forrest (PI)	1998-2004 \$42,1393
National Science Foundation <i>Computer Immunology</i> S. Forrest (PI)	1997-2000 \$292,350
IBM <i>Partnership Award</i> S. Forrest (PI)	1998 \$20,000
Defense Advanced Research Projects Agency <i>Research on a Simple Definition of Normal Behavior for Unix Processes</i> S. Forrest (PI)	1996-98 \$755,728
NSF Research Training Grant <i>A BIO Research Training Group in Ecological Complexity</i> J. H. Brown (PI), S. Forrest, B. T. Milne, J. Rasure, L. M. Simmons, and G. C. Stevens (co-PIs)	1995-2000 \$562,500
Office of Naval Research <i>Research in Computational Immunology</i>	1995-98 \$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)

Publications and Patents (reverse chronological order)

Patents

L. Allen, S. Forrest, and A. S. Perelson. A method of detecting changes to a collection of digital signals. U.S. patent 5448668, Sept. 5 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

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.....

E. Schrom, A. Kinzig, S. Forrest, and 20 other authors. Challenges in cybersecurity: Lessons from biological defense systems. *Proceedings of the National Academy of Sciences*, Submitted, Nov. 2020.

F. Esponda, P. Sulc, J. Blattman, and S. Forrest. A macro-scale public clustering algorithm for analysis of tcr repertoire completeness. *PLOS Computational Biology*, Submitted, Jan. 2021.

M. Ahmadi, K. Leach, R. Dougherty, S. Forrest, and W. Weimer. Reducing malware analysis overhead with coverings. *IEEE Trans. on Dependable and Secure Computing*, Submitted, Jan. 2021.

S. Forrest and R. Axelrod. Coping with societal effects of innovations in computing. *Science*, Submitted, Dec. 2020.

M. Endres, P. Reiter, S. Forrest, and W. Weimer. What can program repair learn from code review? *IEEE Software*, Submitted, Dec. 2020.

R. Miiikkulainen and S. Forrest. A biological perspective on evolutionary computation. *Nature Machine Intelligence*, in press.

D. Jacobs, T. McDaniel, A. Varsani, R. Halden, S. Forrest, and H. Lee. Wastewater monitoring raises privacy and ethical considerations. in press.

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 Transactions of the Royal Society B*, 374(1774), 2019.
- R. Sole, M. Moses, and S. Forrest. Liquid brains, solid brains. *Philosophical Transactions 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 Transactions 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. *Transactions 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.
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