

# James Fairbanks, PhD

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## Education

### Georgia Institute of Technology (Atlanta, GA)

Ph.D Computational Science and Engineering, 2012 – 2016

- ▶ Adviser: Professor David A. Bader
- ▶ Dissertation: *Graph Analysis Combining Numerical Statistical and Streaming Techniques*
- ▶ Qualifier: Computational Data Analysis (ML) and High Performance Computing (HPC)
- ▶ Research Assistant 2012, NDSEG Fellow 2013-16, Teaching Assistant 2016

### University of Florida (Gainesville, FL)

B.S. Mathematics, 2009 – 2012

- ▶ Summa cum laude
- ▶ Thesis: *A Ramsey Theorem for Indecomposable Matchings*

## Work Experience

### University of Florida (Gainesville, FL)

Assistant Professor, Jan 2021 - Present

- ▶ Leading the Generalized Algebraic Techniques Advancing Science (GATAS) Lab
- ▶ Research focus: advancing computational science and engineering with the techniques of applied category theory
- ▶ Teaching focus: scientific computing

### Georgia Tech Research Institute (GTRI) (Atlanta, GA)

Research Engineer, May 2016 - Dec 2020

- ▶ Conduct research into high performance data analysis algorithms and applications
- ▶ Win and manage federally funded research contracts
- ▶ Deliver applied research projects to sponsors such as source code, web applications, technical reports
- ▶ Mentor and advise students in connection to research projects

### Ionic Security (Atlanta, GA)

Data Scientist, 2015

- ▶ Developed data analytics software
- ▶ Designed a service oriented architecture for near real time analysis written in Go and Julia
- ▶ Leveraged time series and network database technologies including Heka, InfluxDB, RabbitMQ, and Elasticsearch

### DOE – Lawrence Livermore National Laboratory (Livermore, CA)

Institute for Scientific Computing Research Intern, 2014

- ▶ Studied relationship between numerical accuracy of eigensolvers and solution quality of mincut graph partitioning
- ▶ Developed very fast approximate eigensolvers for large graphs
- ▶ Applied probabilistic reasoning to describe numerical computations
- ▶ Presented results at LLNL poster session

### IDA – Center for Computing Sciences (Bowie, MD)

Adjunct Faculty, 2013

- ▶ Conducted research into Malware structure and similarities by studying execution patterns of malicious programs
- ▶ Developed clustering and methods for understanding the structure of malicious programs with graph analytics
- ▶ Built a high performance distributed system for conducting these analyses with ZeroMQ communication

## Funding

Research funding is summarized in Table 1

Dates	Role	Agency	Title	Amount
2022 – 2026	Principal Investigator	DARPA	ASKEM: Generalized Algebraic Techniques Advancing Scientific Discovery	5.8M
2022 – 2023	Principal Investigator	DARPA	Director’s Fellowship: Model Aware Scientific Computing	250K
2022 – 2025	Co-PI	DARPA	Perceptual Task Guidance: ENKIX	4.8M
2020 – 2022	Principal Investigator	DARPA	Young Faculty Award: Model Aware Scientific Computing	500K
2020 – 2021	Principal Investigator	DARPA	AIE: Automating Scientific Knowledge Extraction Extended	700K
2019 – 2021	Principal Investigator	DARPA	Directly Computable Models: Generalized Algebraic Theories Enhancing Multiphysics	1M
2018 – 2020	Principal Investigator	DARPA	Artificial Intelligence Exporation: Automating Scientific Knowledge Extraction	1M
2019 – 2023	Principal Investigator	DARPA	Artificial Social Intelligence for Successful Teams (ASIST)	400K
2016 – 2018	Principal Investigator	NIJ	Developing Novel Means of Evidence Collection	400K
2019 – 2022	Co-PI	ONR	Extracting, Explaining, and Estimating Information in Sonar Data (E3ISD)	695K
2019 – 2021	Co-PI	ONR	Mine Counter-measures Situational Awareness	375K
2016 – 2019	Key Personnel	ONR	Performance Estimation of Underwater Mine Counter-measures Operations	990K
2016 – 2019	Key Personnel	GTRI SI	Multi-source Anticipatory Intelligence	900K

Table 1: Funded Projects. Abbreviations: ONR: Office of Naval Research, DARPA: Defense Advanced Research Projects Agency, NIJ: National Institutes of Justice, GTRI SI: Internally funded strategic initiative. Amounts rounded \$1000

## Teaching

### University of Florida

Spring 2021 COT 4501 - Numerical Analysis a Computational Approach

Fall 2021 CIS 4930 - Abstraction Composition Computation

Fall 2021 CIS 6930 - Abstraction Composition Computation

### Professional Education

Aug 2022 CANMOD Mathematical and Computational Modeling of Epidemics Workshop, Organizer and Instructor 1 week training for mathematical epidemiologists to learn applied category theoretic tools

Spring 2021 ACT Adjoint School Instructor

Spring 2019 Data Analytics Methodology with J. Poovey

Fall 2018 Programming for Data Science with Beverly Wright

Spring 2017 Data Analytics Methodology with J. Poovey, D. Ediger, and M. Rost.

Fall 2016 Big Data Analytics with J. Poovey, D. Ediger, and M. Rost.

### Teaching Assistant at Georgia Tech

Spring 2016 CSE 6643 Numerical Linear Algebra with Prof. Haesun Park

Spring 2014 CSE 6220 High Performance Computing with Prof. Srinivas Aluru

## Research

### Peer Reviewed Journal Articles

- ▶ *An Algebraic Framework for Rapid Epidemic Modeling*, S. Libkind, A. Baas, M. Halter, E. Patterson, and J. P. Fairbanks, Proc. of the Royal Society Phil. Trans., Aug 2022
- ▶ *The application of applied category theory to quantify mission success*, R. Garrett, J. Fairbanks, M. Loper, J. Moreland, Simulation, Aug 2022

- ▶ *A Diagrammatic View of Differential Equations in Physics*, E. Patterson, A. Baas, T. Hosgood, J. P. Fairbanks, Mathematics in Engineering, May 2022
- ▶ *Categorical Data Structures for Technical Computing*, E. J. Patterson, O. Lynch, J. P. Fairbanks, Compositionality, Feb 2022
- ▶ *Category-theoretic formulation of the model-based systems architecting cognitive-computational Cycle*, Y. Mordecai, J. P. Fairbanks, E.F. Crawley, MDPI Applied Sciences, Jan 2021
- ▶ *Spectral Partitioning with Blends of Eigenvectors*, J. P. Fairbanks, D. A. Bader, G. D. Sanders, Journal of Complex Networks, 2017
- ▶ *Behavioral Clusters in Dynamic Graphs*, J. P. Fairbanks, R. Kannan, H. Park, D. A. Bader, Parallel Computing Special Issue of Scientific Graph Analysis, 2015
- ▶ *A Ramsey Theorem for Indecomposable Matchings*, J. P. Fairbanks, Electronic Journal of Combinatorics, Vol 18(1), Dec 2011

### Peer Reviewed Conference Publications

- ▶ *Compositional Exploration of Combinatorial Scientific Models*, K. Brown, T. Hanks, J. P. Fairbanks, Applied Category Theory, Jul 2022
- ▶ *Computational Category-Theoretic Rewriting*, K. Brown, E. Patterson, T. Hanks, J. P. Fairbanks, International Conference on Graph Transformation, Jul 2022
- ▶ *Operadic Modeling of Dynamical Systems: Mathematics and Computation*, S. Libkind, A. Baas, E. J. Patterson, J. P. Fairbanks, Applied category Theory, Jul 2021
- ▶ *SemanticModels.jl: A Julia Package for Scientific Model Augmentation*, M. Halter, S. Raparti, K. Cao, C. Herlihy, J. P. Fairbanks, Proceedings of the JuliaCon Conferences, Jul 2020
- ▶ *Constructing Knowledge Graphs from Scientific Texts*, K. Cao, J. P. Fairbanks, KDD workshop on Machine Learning in Graphs, Aug 2019
- ▶ *A Compositional Framework for Scientific Model Augmentation*, M. Halter, C. Herlihy, J. P. Fairbanks, Applied Category Theory, July 2019
- ▶ *Semantic Program Analysis for Scientific Model Augmentation*, J. P. Fairbanks, C. Herlihy, K. Cao, S. Reparthi, Modeling the Worlds Systems, May 2019
- ▶ *Digital Witness: Remote Methods for Volunteering Digital Evidence on Mobile Devices*, N. Campbell, T. Goodyear, W. Messer, E. Stuart, J. P. Fairbanks, IEEE Technologies for Homeland Security, Oct 2018
- ▶ *Performance Effects of Backing Data Stores in Community Detection Algorithms*, R. Varkey Thankachan, B. P. Swenson, J. P. Fairbanks, IEEE High Performance Extreme Computing, Sep 2018
- ▶ *Credibility Assessment in the News: Do we need to read?*, N. Fitch, N. Knauf, J. P. Fairbanks, E. Briscoe, ACM WSDM MIS2, Feb 2018
- ▶ *Integrating Productivity-Oriented Programming Languages with High-Performance Data Structures*, R. Varkey Thankachan, E. Hein, B. P. Swenson, J. P. Fairbanks, IEEE High Performance Extreme Computing, Sep 2017
- ▶ *Deriving Streaming Graph Algorithms from Static Definitions*, J. P. Fairbanks, D. M. Ediger, IEEE International Parallel and Distributed Processing Graph Algorithms Building Blocks, 2017
- ▶ *Graph Partitioning with Spectral Blends*, J. P. Fairbanks, D. A. Bader, and G. D. Sanders, Oxford Journal of Complex Networks, Jan 2017
- ▶ *Ranking in Dynamic Graphs Using Exponential Centrality*, E. Nathan, J. P. Fairbanks, D. A. Bader, International Conference on Complex Networks and their Applications, 2017
- ▶ *Graph Ranking Guarantees for Numerical Approximations to Katz Centrality*, E. Nathan, G. Sanders, J. P. Fairbanks, V. Henson and D. Bader, International Conference On Computational Science, 2017
- ▶ *Deriving Streaming Graph Algorithms from Static Definitions.*, D. M. Ediger and J. P. Fairbanks, IEEE Parallel and Distributed Processing - Graph Algorithm Building Blocks, 2017
- ▶ *A local measure of community change in dynamic graphs.*, A. Zakrzewska, E. Nathan, J. P. Fairbanks, D. A. Bader, IEEE/ACM ASONAM
- ▶ *Novel Stopping Criteria for Spectral Partitioning*, J. P. Fairbanks, A. Zakrzewska, D.A. Bader, SIAM Network Science, Jul 2016
- ▶ *A Statistical Framework for Analyzing Streaming Graphs*, J. P. Fairbanks, D. Ediger, R. McColl, D.A. Bader, E. Gilbert, IEEE/ACM ASONAM, Aug 2013

### Panels

- ▶ *HWCOE Early Career Researcher Award Panel*, UF ECR Development Workshop, May 2022  
Host: Forrest Masters (UF)
- ▶ *Abstract Representations of Scientific Models*, Paul Cohen (Pitt), Eric Davis (Galois Inc), Alec Nielson (Azimov.io), DARPA ASKE Principal Investigator Meeting, May 2019  
Host: Josh Elliot (DARPA), Moderator: J. P. Fairbanks
- ▶ *Toward the Modeling Stack Panel*, Joshua Elliot (DARPA), John Bachman (Harvard Medical School), Eric Davis (Galois), Clayton Morrison (Arizona), J. P. Fairbanks (GTRI), Modeling the World's Systems 2019, May 2019  
Host: Paul Cohen (Pitt), Moderator: Bruce Childers (Pitt)

### Conference Presentations

- ▶ *Diagrammatic differential equations: Formal categorical framework and applications to multiphysics simulation*, E. Patterson, T. Hosgood (speaker), A. Baas, J. Fairbanks, Applied Category Theory 2022, Jul 2022
- ▶ *Typed and stratified models with slice categories*, S. Libkind (speaker), E. Patterson, A. Baas, M. Halter, J. Fairbanks, Applied Category Theory 2022, Jul 2022
- ▶ *Individual.jl: Rewriting individual-based models for epidemiology using graph rewriting*, S. Wu (speaker), K. Brown, and J. Fairbanks, Applied Category Theory 2022, Jul 2022
- ▶ *AlgebraicDynamics: Compositional dynamical systems*, S. Libkind, J. P. Fairbanks, JuliaCon, Online, Jul 2021
- ▶ *Shaped Data with Acsets*, O. Lynch, E. J. Patterson, J. P. Fairbanks, JuliaCon, Online, Jul 2021
- ▶ *SemanticModels.jl: Not Just Another Modeling Framework*, J. P. Fairbanks and C. R. Herlihy, JuliaCon, Baltimore, MD, Jul 2019
- ▶ *Complex Systems Analysis of Hybrid Warfare*, M. Nadolski and J. P. Fairbanks, Conference on Systems Engineering Research, Apr 2019
- ▶ *Graph Interfaces: Bespoke Graphs for Every Occasion*, M. Besançon, J. P. Fairbanks, JuliaCon, London, UK, 2018
- ▶ *The JuliaGraphs Ecosystem: Move Fast and Don't Break Things*, J. P. Fairbanks, JuliaCon, London, UK, 2018
- ▶ *Assessing Credibility in Global Media Networks*, J. P. Fairbanks, Human Language Technologies, 2017
- ▶ *Using Big Data to Predict and Analyze Cooperation and Conflict*, T. Frederick, C. Herlihy, J. P. Fairbanks, The Conflict Conference at UT-Austin, 2017
- ▶ *LightGraphs: Our Network, Our Story*, S. Bromberger, J. P. Fairbanks, JuliaCon, Berkeley, CA, 2017

### Invited Talks

- ▶ *Computational Physics with Categories*, J. P. Fairbanks, Institute of Theoretical Physics Friedrich-Alexander-Universität Erlangen-Nürnberg, Oct 2022
- ▶ *Using Category Theory to Design Computational Mathematics Software*, J. P. Fairbanks, UF – Numerical Analysis and SIAM seminar, Sept 2022
- ▶ *Model Aware Scientific Computing with Categories*, J. P. Fairbanks, Air Force Research Lab – Information Directorate, Rome, NY, Jun 2022
- ▶ *Diagrammatic Equations in Numerical Multiphysics*, J. P. Fairbanks, Simula Research Laboratory Numerical Analysis Research Seminar (Oslo, NO), May 2022
- ▶ *Introduction to Applied Category Theory*, J. P. Fairbanks, Simula Research Laboratory Coffee and Theorems (Oslo, NO), May 2022
- ▶ *Scientific Modeling with AlgebraicJulia*, J. P. Fairbanks, Rel.ai Research Seminar, Mar 2022
- ▶ *Automated Model Space Exploration*, K. Brown and J. P. Fairbanks, Topos Institute and UW-IHME Compositional Epidemiology Modeling Working Group, Spring 2022
- ▶ *Compositional Modeling of Disease Dynamics*, S. Libkind and J. P. Fairbanks, Topos Institute and UW-IHME Compositional Epidemiology Modeling Working Group, Fall 2022
- ▶ *Computational Modeling with Category Theory*, J. P. Fairbanks, UF College of Medicine – Laboratory for Systems Medicine, Jan 2022
- ▶ *Compositional Modeling with AlgebraicJulia*, E. J. Patterson and J. P. Fairbanks, NIH IMAG MSM Viral Pandemic Meetings, Jul 2021
- ▶ *The Algebraic Julia Ecosystem, a categorical approach to technical computing*, J. P. Fairbanks, Topos Institute Berkeley Seminar, Jun 2021
- ▶ *Computational Categorical Algebra with Catlab*, J. P. Fairbanks, Greta: Graph Transformation, Theory, and Applications Seminar, May 2021

- ▶ *Introduction to the AlgebraicJulia Software Ecosystem*, J. P. Fairbanks, UF CISE and LLNL Advisory Board Annual Meeting, Feb 2021
- ▶ *Rethinking Set Theory and Applications*, J. P. Fairbanks, UF University Math Society, Feb 2021
- ▶ *Model Aware Scientific Computing with Categories*, J. P. Fairbanks, DARPA Young Faculty Award Principal Investigators Meeting Poster Session, Feb 2021
- ▶ *Automating Model Fusion with Decorated Cospan Categories*, J. P. Fairbanks, MIT Category Theory Seminar, Feb 2020
- ▶ *Model IR Working Group: Initial Progress*, J. P. Fairbanks, E. Davis, C. Morrison, DARPA ASKE Program Meeting, Jun 2019
- ▶ *Semantic Program Analysis for Scientific Model Augmentation*, J. P. Fairbanks, Lawrence Livermore National Lab, April 2019
- ▶ *Program Analysis for Scientific Model Augmentation*, J. P. Fairbanks, University of Florida Informatics Institute Spring Symposium, March 2019
- ▶ *Data Science and Graph Analytics with Julia*, J. P. Fairbanks, University of Florida Informatics Institute, Nov 2018
- ▶ *Solving Applied Graph Theory Problems in the JuliaGraphs ecosystem*, J. P. Fairbanks, MIT CSAIL Seminar, 2018

### Posters

- ▶ *Parameter Estimation by Minimizing the Loss with Respect to a Finite Difference Approximation on the Vector Field*, J. L. Perez, A. Baas, M. C. Ferrall-Fairbanks, M. O. Platt, J. P. Fairbanks, Biomedical Engineering Society Annual Meeting, Oct 2021
- ▶ *Graphical Semantic Modeling with Semagrams.jl*, O. Lynch, J. P. Fairbanks, E. J. Patterson, Applied Category Theory 2021, June 2021
- ▶ *Semantic Model Understanding for Scientific Model Augmentation*, J. P. Fairbanks, Systems Biology of Human Disease, (Berlin, GER), May 2019
- ▶ *QueryGarden: growing healthy applications in well prepared SQL*, J. P. Fairbanks, OHDSI Symposium, 2017
- ▶ *Implementing Real-Time Patient Level Predictions Using PLP Models*, C. S. Brown, J. D. Duke, J. P. Fairbanks, C. Herlihy, K. Mukadam, J. Poovey, M. Rost, OHDSI Symposium, 2017
- ▶ *Discovering Block Structure with Approximate Eigenvectors*, SIAM Computational Science and Engineering, Mar 2015
- ▶ *Ramsey Theorem for Indecomposable Matchings*, Graph Theory at Georgia Tech (GT@GT), 2012

### Technical Reports

- ▶ *Remote Methods for Volunteering Digital Evidence on Mobile Devices*, E. Stuart, J. P. Fairbanks, National Institutes of Justice, Dec 2018

## Open Source

Core Developer of *AlgebraicJulia*, the premier applied category theory software ecosystem.

Lead Developer of *SemanticModels*, a *Julia* package for representing scientific modes in a category theoretic framework.

Core maintainer of *Graphs.jl* the most widely used Graph Algorithm Package in *Julia*.

Developer of *STINGER* the fastest streaming dynamic graph library for shared memory parallel computers.

An up to date list of miscellaneous contributions can be found at <https://github.com/jpfairbanks>

## Achievements

### Honors, Awards, and Fellowships

- May 2022 American Mathematical Society: Mathematical Research Community on Applied Category Theory
- 2018 Office of the Director of National Intelligence – XAMINE Challenge
- 2013-16 National Defense Science and Engineering Fellowship
- 2012-16 Presidential Fellowship for Graduate Study at Georgia Tech
- 2011-12 University Scholar at the University of Florida
- 2012 Kermit Sigmon Scholarship for service to the mathematical community
- 2015 Tau Beta Pi, Engineering Honor Society, Georgia Tech Chapter
- 2012 Phi Beta Kappa, University of Florida Chapter

## Leadership and Service

- 2022 Proposal Referee: Army Research Office, Topic: Network Science
- 2022 Journal Referee: Compositionality
- 2023 Applied Category Theory Conference General Chair and Program Committee Member
- 2022 Applied Category Theory Conference Organizer and Program Committee Member
- Aug 2022 DARPA AI Strategy meeting for UF
  
- Spring 2021 Upper Division Curriculum Committee
  - Developed Syllabi for new courses in CISE, including COP 4533 Algorithms Abstraction and Design
- Spring 2021 Programming Language Task Force
- Feb 2021 PhD Student Recruitment Panel
- 2019 JuliaCon Organizing Program Committee
- 2018 JuliaCon Organizing Committee Vice Program Chair
  - Organized the technical program of a 3 day international conference on the Julia programming language
  - Ran Program Committee meetings to decide on accepted abstracts and presentations
  - Led poster session preparations
- 2017 Tau Beta Pi Atlanta Alumni Chapter President
  - Organized professional networking events for local Atlanta Area Engineers
- 2015 Georgia Tech College of Computing Graduate Student Association VP for the School of CSE
  - Represented department students to university administration committees on curriculum and funding
  - Organized social and professional networking events for graduate students
  - Chaired the organizing committee of HotCSE graduate research seminar providing early career presentation opportunities to graduate students
- 2011 Univ. Florida Pi Mu Epsilon Chapter President
  - Organized a series of talks for the mathematics students at UF on diverse mathematical topics and skills incl. LaTeX, programming and technical communication in the field.
- 2009 Eagle Scout

## Mentoring

- 2022-2023 University Multicultural Mentoring Program, BS 2022, UMMP Mentor
- 2022-Present Adam Gregory, *PhD 2022*, Thesis Committee
- 2022-Present Hong Yu, *PhD 2022*, Thesis Committee
- 2022-Present Daniel A. Delgado, *PhD 2022*, Thesis Committee
- 2021-Present Luke Morris, *PhD 2021*, Thesis Advisor
- 2021-Present Tyler Hanks, *PhD Student, NSF GRFP Fellow 2021*, Thesis Advisor
  - 2021-22 Kris Brown, *Post-Doctoral Researcher 2022*, UF
    - 2021 UF HWCOE Mentoring Academy Participant, 2021,
    - 2021 ACT Adjoint School, 2021, A. Knoerr, G. Generaux, A. Searle
  - 2021-2022 Kris Brown, *Chemical Engineering, Stanford University 2021*,
- 2020-Present Sophie Libkind, *Mathematics, Stanford University 2021*,
- 2020-Present Owen Lynch, *Statistics University of Utrecht 2021*,
  - 2021-22 Julian Perez, *BS BME GT 2021*,
  - 2021 Stephen Wellburg, *BS DAS UF 2021*,
- 2018-19 Sreenath Reparti, *BS ISYE Georgia Tech 2019*, KPMG
  - 2019 Kun Cao, *MS CS Georgia Tech 2019*, GT
  - 2019 Abhinav Mehndiratta, 2019, Google Summer of Code
- 2016-18 Rohit Varkey, *MS CS Georgia Tech 2018*, Google
- 2016-19 Micah Halter, *BS CS Georgia Tech 2019*, GTRI
  - 2016 Nate Knauf, *BS CS Georgia Tech 2019*, GT
  - 2015 Pushkar Godbole, *MS CSE Georgia Tech 2016*, Yelp

## Selected Technical Skills

Programming languages (most familiar to least) Julia, Golang, SQL, Python, C, Bash  
Computational Data Analysis (pandas, sklearn, Jupyter)  
Web development with Golang and Python (flask)  
Database Applications primarily with PostgreSQL and MongoDB  
Practical computing skills such as LINUX, git, make, L<sup>A</sup>T<sub>E</sub>X  
Continuous Integration/Deployment