Mohan **Krishnamoorthy**

RESEARCH & DEVELOPMENT · SCIENTIFIC ENGINEER & PROGRAMMER

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Research interests

Model-driven and algorithm engineering; global optimization; derivative-free optimization; big data analytics; high performance computing

Education

George Mason University	*Fairfax, VA, USA*
PH.D. IN COMPUTER SCIENCE (ADVISORS: PROF. ALEXANDER BRODSKY, PROF. DANIEL MENASCÉ)	*2012–2018*
Rochester Institute of Technology	*Rochester, NY, USA*
MASTER OF SCIENCE IN COMPUTER SCIENCE	*2007–2010*
Mumbai University	*Mumbai, INDIA*
BACHELOR OF ENGINEERING IN COMPUTER ENGINEERING	*2003–2007*

Positions held

RESEARCH CONSULTANT, ARGONNE NATIONAL LABORATORY, GREATER TORONTO AREA, ON, CANADA	*01/2022–Present*
POSTDOCTORAL APPOINTEE, ARGONNE NATIONAL LABORATORY, LEMONT, IL, USA	*10/2018–09/2021*
GRADUATE RESEARCH ASSISTANT, GEORGE MASON UNIVERSITY, FAIRFAX, VA, USA	*01/2013–08/2018*
GUEST RESEARCHER, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, GAITHERSBURGH, MD, USA	*01/2015–12/2017*
GRADUATE TEACHING ASSISTANT, GEORGE MASON UNIVERSITY, FAIRFAX, VA, USA	*08/2012–12/2012*
RESEARCH TECHNOLOGIST, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM, USA	*05/2010–06/2012*
RESEARCH ASSISTANT, LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS, NM, USA	*07/2008–04/2010*

Software packages

Apprentice ↗ *apprentice*

An open source High Energy Physics analysis package. Construct polynomial and rational approximations of a given order and perform χ^2 minimization with diagonal variance or full covariance matrix.

Outer optimization ↗ *outer opt*

An open source package to assign weights and solve the tuning problem of finding optimal parameters that minimizes the a least-squares function between approximations of noisy simulations and experimental data or data observed in nature. Instead of setting weights manually based on experience and intuition, the weights are automatically adjusted using a bilevel optimization or a single level robust optimization formulation, thus yielding results efficiently that are less subjective.

Workflow ↗ *workflow*

An open source package to solve the problem of directly fitting Monte Carlo simulations to experimental data or data observed in nature. This is achieved using a stochastic trust-region optimization algorithm. Currently working on integrating this workflow with Pythia DIY PyCOMPSs workflow to solve the derivative free optimization problem with model values obtained from the physics Monte Carlo simulator (Pythia) in a high performance computing environment.

SODA ↗ *soda*

An open source package containing the algorithm to perform stochastic optimization based on deterministic approximations to efficiently solve the problem of finding control settings for stochastic processes in a large manufacturing service network subject to the satisfaction of stochastic feasibility constraints.

Factory optima ↗ *factory optima*

Web-based prototype system that allows manufacturing process engineers to compose, optimize and perform trade-off analysis of manufacturing service networks based on a reusable repository of performance models.

Peer-reviewed journal articles

BROOD: Bilevel and Robust Optimization and Outlier Detection for Efficient Tuning of High-Energy Physics Event Generators. ↗ *SCIPOST'22*

W. Wang, M. Krishnamoorthy, J. Muller, S. Mrenna, H. Schulz, X. Ju, S. Leyffer, Z. Marshall. In the SciPost Physics. January 2022.

Practical algorithms for multivariate rational approximation ↗ *CPC'20*

A. Austin, M. Krishnamoorthy, S. Leyffer, S. Mrenna, J. Muller, H. Schulz. In the Computer Physics Communications, October 2020.

Factory optima: a web-based system for composition and analysis of manufacturing service networks based on a reusable model repository ↗ *IJCIM'19*

A. Brodsky, M. O. Nachawati, M. Krishnamoorthy, W. Z. Bernstein, and D. A. Menascé. In the International Journal of Computer Integrated Manufacturing, February 2019.

Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation ↗ *JDS'18*

M. Krishnamoorthy, A. Brodsky, and D. Menascé. In the Journal of Decision Systems. May 2018.

Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models ↗ *IJAMT'16*

A. Brodsky, G. Shao, M. Krishnamoorthy, A. Narayanan, D Menascé, and R. Ak. In the International Journal of Advanced Manufacturing Technology. April 2016.

Autonomic Smart Manufacturing ↗ *JDS'15*

D. Menascé, M. Krishnamoorthy, A. Brodsky. In the Journal of Decision Systems, Special Issue on Integrated Decision Support Systems, June 2015.

A multiple-alignment based primer design algorithm for genetically highly variable DNA targets ↗ *BMCbio'13*

J. Brodin, M. Krishnamoorthy, G. Athreya, W. Fischer, P. Hraber, C. Gleasner, L. Green, B. Korber, T. Leitner. In BMC bioinformatics Journal, August 2013.

Tree pruner: An efficient tool for selecting data from a biased genetic database ↗ *BMCbio'11*

M. Krishnamoorthy, P. Patel, M. Dimitrijevic, J. Dietrich, M. Green, C. Macken. In BMC bioinformatics Journal, January 2011.

Peer-reviewed conference publications & workshops

Apprentice for Event Generator Tuning ↗ *CHEP'21*

M. Krishnamoorthy, H. Schulz, X. Ju, W. Wang, S. Leyffer, Z. Marshall, S. Mrenna, J. Muller, and J. B.Kowalkowski. In 25th International Conference on Computing in High-Energy and Nuclear Physics. August 2021.

Stochastic Optimization for Steady State Production Processes based on Deterministic Approximations ↗ *ICORES'21*

M. Krishnamoorthy, A. Brodsky, D. Menascé. In the International Conference on Operations Research and Enterprise Systems 2021, February 2021.

Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation ↗ *IFIP-DSS'18*

M. Krishnamoorthy, A. Brodsky, and D. Menascé. In Proceedings of the IFIP WG 8.3 on Decision Support Systems, June 2018. Best Paper Award.

Manufacturing and Contract Service Networks: Composition, Optimization and Tradeoff Analysis based on a Reusable Repository of Performance Models ↗ *IEEE-BD'17*

A. Brodsky, M. Krishnamoorthy, M. O. Nachawati, and W.Z. Bernstein, D Menascé. In Proceedings of the 2017 IEEE International Conference on Big Data, Boston, MA. December 2017.

A System and Architecture for Reusable Abstractions of Manufacturing Processes ↗ *IEEE-BD'16*

A. Brodsky, M. Krishnamoorthy, W. Z. Bernstein, M. O. Nachawati. In Proceedings of the 2016 IEEE International Conference on Big Data, Washington DC. December 2016.

Modular Modeling and Optimization of Temporal Manufacturing Processes with Inventories ↗ *HICSS'16*

M. Krishnamoorthy, A. Brodsky, and D. Menascé. In Proceedings of the 2016 Hawaii International Conference on System Sciences, Kauai, HI. January 2016.

Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models ↗ *IEEE-BD'15*

A. Brodsky, G. Shao, M. Krishnamoorthy, A. Narayanan, D Menascé, and R. Ak. In Proceedings of the 2015 IEEE International Conference on Big Data, Santa Clara, CA. November 2015.

Optimizing Stochastic Temporal Manufacturing Processes with Inventories: An Efficient Heuristic Algorithm Based on Deterministic Approximations ↗ *ICS'15*

M. Krishnamoorthy, A. Brodsky, D. Menascé. In Proceedings of 2015 INFORMS Computing Soc. Conf., Richmond, VA. January 2015

Temporal manufacturing query language (tMQL) for domain specific composition, what-if analysis, and optimization of manufacturing processes with inventories ↗ *GMU'14 (TR)*

M. Krishnamoorthy, A. Brodsky, and D. A. Menascé. Technical Report Department of Computer Science, George Mason University, 2014. Also presented at the 2015 INFORMS Computing Soc. Conf. workshop, Richmond, VA. January 2015.

Toward Smart Manufacturing Using Decision Analytics ↗ *IEEE-BD'14*

A. Brodsky, M. Krishnamoorthy, D. Menascé, G. Shao, S.Rachuri. In Proceedings of the 2014 IEEE International Conference on Big Data, Washington DC. October 2014.

Talks

2021	**Apprentice for Event Generator Tuning**, 25th International Conference on Computing in High Energy and Nuclear Physics	*Paris, France (Online)*
2021	**Stochastic Optimization Algorithm based on Deterministic Approximations**, International Conference on Operations Research and Enterprise Systems	*Vienna, Austria (Online)*
2020	**A Framework for Large-Scale Nonlinear Optimization**, SIAM Conference on Parallel Processing for Scientific Computing	*Seattle, WA*
2019	**Bi-level Optimization for Design of Experiments**, INFORMS Annual Meeting	*Seattle, WA*
2018	**Optimization based on White-Box Deterministic Approximations: Models, Algorithms, and Application to Service Networks**, Argonne National Laboratory,	*Lemont, IL*
2017	**Service Networks: Stochastic Optimization based on Deterministic Approximations and Repository of Performance Models**, Doctoral Candidate Student Presentations at the 29th International Conference on Tools for Artificial Intelligence	*Boston, MA*
2017	**Manufacturing and Contract Service Networks: Composition, Optimization and Tradeoff Analysis based on a Reusable Repository of Performance Models**, IEEE International Conference on Big Data	*Boston, MA*
2016	**A System and Architecture for Reusable Abstractions of Manufacturing Processes**, IEEE International Conference on Big Data	*Washington DC*
2016	**Efficient Decision Support System for Discrete Manufacturing Processes**, Computer Science PhD Symposium, George Mason University	*Fairfax, VA*
2015	**Analysis and Optimization in Smart Manufacturing based on a Reusable Knowledge Base for Process Performance Models**, IEEE International Conference on Big Data	*Santa Clara, CA*
2015	**Temporal manufacturing query language (tMQL) for domain specific composition, what-if analysis, and optimization of manufacturing processes with inventories**, INFORMS Computing Society Conference	*Richmond, VA*
2015	**Optimizing Stochastic Temporal Manufacturing Processes with Inventories: An Efficient Heuristic Algorithm Based on Deterministic Approximations**, INFORMS Computing Society Conference	*Richmond, VA*
2010	**Tree prune & decorator: An efficient tool for selecting and annotating data from a biased genetic database**, Theoretical Biology and Biophysics Seminar, Los Alamos National Laboratory	*Los Alamos, NM*

Awards & accomplishments

2021	**Travel Grant (conference registration fee vaiwer) to attend and present**, at the International Conference on Operations Research and Enterprise Systems	*Vienna, Austria (Online)*
2018	**Best Paper Award for the paper "Stochastic Decision Optimization based on Deterministic Approximations of Processes described as Closed-form Arithmetic Simulation"**, IFIP WG 8.3 on Decision Support Systems	*Ljubljana, Slovenia*
2018	**Outstanding PhD Student Award**, from Computer Science Dept. at George Mason University	*Fairfax, VA*
2017	**Travel Grant**, International Conference on Tools for Artificial Intelligence	*Boston, MA*
2017	**Travel Grant**, IEEE International Conference on Big Data	*Boston, MA*
2016	**Travel Grant**, IEEE International Conference on Big Data	*Washington DC*
2015	**Travel Grant**, IEEE International Conference on Big Data	*Santa Clara, CA*
2015	**Travel Grant**, INFORMS Computing Society Conference	*Richmond, VA*
2015–2017	**Research Grant**, National Institute of Standards and Technology	*Gaithersburgh, MD*
2014	**Travel Grant**, IEEE International Conference on Big Data	*Washington DC*
2014–2017	**Proposals**, NIST and DFW airport, two of which were successfully funded	*Gaithersburgh, MD; Dallas, TX*
2013–2018	**Graduate Research assistantship**, George Mason University	*Fairfax, VA*
2012–2013	**Dean Fellowship Award**, George Mason University	*Fairfax, VA*
2008–2010	**Research Assistantship**, Los Alamos National Laboratory	*Los Alamos, NM*
2007	**Certificate of excellence**, budget database back end in SQL Server and web user interface for monitoring quarterly budgets	*Mumbai, India*

Research experience

Argonne National Laboratory (ANL)   *Greater Toronto Area, ON*

Research Consultant   *01/2022–Present*
- Currently developing mathematical and algorithmic techniques for directly fitting Monte Carlo simulations to experimental data or data observed in nature using a stochastic trust-region optimization algorithm.
- Currently developing a workflow package to efficiently solve derivate-free stochastic optimization problems in a high performance computing environment.

Argonne National Laboratory (ANL)   *Lemont, IL*

Postdoctoral Appointee   *10/2018–09/2021*
- Developed and implemented mathematical and algorithmic techniques for approximating expensive functions in High Energy Physics (HEP).
- Developed robust optimization and design of experiment formulations to decide weights of importance with the goal of tuning a HEP Monte Carlo simulator.
- Developed, maintained, and published HEP analysis packages called *apprentice* and *outer optimization* for efficiently constructing polynomial/rational approximations and for performing χ^2 minimizations.

George Mason University (GMU)   *Fairfax, VA*

Graduate Research Assistant   *01/2013–08/2018*
- Designed and developed reusable mathematical models for non-linear, stochastic, hierarchical, and temporal manufacturing processes from real-world data.
- Designed and developed one-stage stochastic optimization algorithms based on deterministic approximation heuristics.
- Developed and published the stochastic optimization algorithm based on deterministic approximations (*SODA*) to efficiently solve the problem of finding controls for stochastic processes in a large manufacturing service network.

National Institute of Standards and Technology (NIST)   *Gaithersburgh, MD*

Guest Researcher   *01/2015–12/2017*
- Designed and populated a repository of reusable mathematical models that were sourced from real-world data, publications, and crowdsourced data.
- Developed a software framework and prototype (*FactoryOptima*) to perform composition, analysis, and optimization on reusable models.

Los Alamos National Laboratory (LANL)   *Los Alamos, NM*

Research Technologist   *05/2010–06/2012*
- Designed and developed scientific algorithms for highly variable and large scale bioinformatics tools.
- Developed and debugged multiple backend modules of the HIV project.
- Redesigned the HIV website using Model-View-Controller (MVC) framework and web services.

Los Alamos National Laboratory (LANL)   *Los Alamos, NM*

Research Assistant   *07/2008–04/2010*
- Designed and developed Tree Viewer, Pruner and Decorator tools to perform selection and annotation of Influenza sequences.
- Designed and developed a schema for a large Influenza Sequence Database.

Teaching Experience

George Mason University (GMU)   *Fairfax, VA*

Mentor   *01/2015–05/2015*

Mentored a graduate student in *Advanced Algorithms* course.

George Mason University (GMU)   *Fairfax, VA*

Mentor   *01/2014–05/2014*

Mentored undergraduate students in *Logic Programming* and *Java* courses and graduate students in *Decision Guidance Systems* course.

George Mason University (GMU)   *Fairfax, VA*

Graduate Teaching Assistant   *08/2012–12/2012*

Prepared and conducted labs, discussions, quizzes, and examinations of undergraduate courses in C/C++.

Computer Programming Institute   *Mumbai, INDIA*

Instructor   *Summer 2007*

Instructor in a private computer programming institute. Taught *Programming with C++*, *Java*, and *Database programming*.

Professional service

Supervising

| 2020 | **Supervised a graduate student over the summer to do research on parameter tuning using Monte Carlo simulations**, Argonne National Laboratory | *Lemont, IL* |
| 2019 | **Supervised a graduate student over the summer to do research on design of HEP experiments**, Argonne National Laboratory | *Lemont, IL* |

Minisymposia

2020	**Co-organized a mini symposium titled "High Performance Computing in Scientific Applications"**, 19th SIAM Conference on Parallel Processing for Scientific Computing	*Seattle, WA*
2019	**Co-organized a a mini symposium titled "Simulation-Based Optimization and Design of Experiments"**, INFORMS Annual Meeting	*Seattle, WA*

Mentoring

2014	**Mentored graduate students in *Advanced Algorithms* and *Decision Guidance Systems* courses**, George Mason University	*Fairfax, VA*
2014	**Mentored undergraduate students in *Logic Programming* and *C++ Programming* courses**, George Mason University	*Fairfax, VA*

Reviews

Journal of Decision Systems, Hawaii International Conference on System Sciences, INFORMS Computing Society Conference, Winter Simulation Conference, IEEE Conference on Inventive Computing and Informatics, BMC Bioinformatics, IEEE Big Data 2019

Skills, expertise & tools

Programming Languages & Libraries	Java (expert), C (proficient), C++ (proficient), LaTex (proficient), SQL (proficient), NoSQL (proficient), Ruby (familiar), Perl (proficient), Python (proficient), Shell script (familiar), R (proficient), JavaScript (familiar), jQuery (familiar), XQuery (competent), JSONiq (proficient)
Technical Skills	Data analytics, Analytical Modeling, Data Science, Algorithm Design, Decision Optimization, Operations Research, Decision Systems, Model Simulation & Prediction, Database Management Systems, Software Development Life Cycle
OS	Linux, Windows 7/8/10, MAC OS/X
Version control	GIT, Repo, SVN
Functional abilities	Software Architecture, Object Oriented Programming, Distributed Business and Scientific Applications, Software Development and Testing, Data Mining and Analytics
Tools	Docker, Eclipse, Emacs and VI editors, Oxygen XML editor, Rational Rose, Microsoft Visio, Microsoft Office, Microsoft Visual C++, Microsoft Visual Studio, gedit, Atom
Mathematical modeling & Optimization Solvers/MP	OPL, AMPL, CPLEX, Gurobi, MINOS, SNOPT, LGO, Coin OR, BARON, BONMIN
Internet Technology	Amazon AWS, Azure, Hadoop, OpenStack, Apache Spark

Research project details (Last updated August 2018)

George Mason University *Fairfax, VA*

STOCHASTIC OPTIMIZATION ALGORITHMS BASED ON DETERMINISTIC APPROXIMATIONS *08/2014–08/2018*

Purpose: Stochastic optimization algorithms that make use of the mathematical structure of the original problem are inefficient especially for real-world processes composed of complex process networks because they extract the mathematical structure using samples from a black-box simulation. The goal here is to improve the computation complexity and convergence of these algorithms for probabilistic models.

Contribution: Extracted the mathematical structure of the problem from a white-box simulation code analysis as part of a heuristic algorithm based on deterministic approximations to find the most optimal decision points for the system using statistics of the simulated probabilistic model.

Results: Experimental study on a 22-variable and 21-constraint real-world use case demonstrated that this approach significantly outperforms popular simulation-based optimization approaches. (**ICS'15, JDS'18, IFIP-DSS'18**)

National Institute of Standards and Technology
Gaithersburgh, MD

FRAMEWORK FOR COMPOSITION, ANALYSIS, AND OPTIMIZATION OF REAL-WORLD PROCESSES — 01/2016–12/2017

Purpose: To build a system of reusable process models in manufacturing such that it is easy to use, simple, and cost-effective so that the end user can perform multiple analysis and optimization operations on these models.
Contribution: Built a software framework and prototype using Generic Model Environment and cloud architectures that allowed hierarchical composition, visualization, and analysis of manufacturing systems consisting of real-world processes from a reusable model repository.
Results: Demonstrated the prototype system to compose an hierarchical model for a real-world supply chain use case and performed simulation, prediction, optimization, and trade-off analysis using Pareto optimal graphs on this model. (**IEEE-BD'16, IEEE-BD'17**)

National Institute of Standards and Technology & George Mason University
Gaithersburgh, MD; Fairfax, VA

REUSABLE REPOSITORY OF PROCESS PERFORMANCE MODELS — 01/2015–12/2017

Purpose: To build a reusable repository of models for manufacturing so that analysis and optimization solutions need not be implemented *de novo* because it leads to cost and time intensive development of models and algorithms, which are difficult to modify, extend, and reuse.
Contribution: Designed and developed a reusable repository of mathematical models called performance models for manufacturing end-users with the goal of ease of use and reusability to compose and perform analysis and optimization on complex real-world hierarchical processes.
Results: This repository was used as the basis for a competition to crowdsource Reusable Abstractions of Manufacturing Processes (RAMP) (tinyurl.com/y8fyakcl). For this competition, I also demonstrated the structure of a process performance model in an instructional webinar available at tinyurl.com/y87q4udv (**IEEE-BD'14, ICS-pr'15, JDS'15, IEEE-BD'15, IJAMT'16, HICSS'16**)

Los Alamos National Laboratory
Los Alamos, NM

SCIENTIFIC ALGORITHM FOR PRIMER DESIGN — 01/2011–07/2011

Purpose: To build a tool for primer design, which is difficult to do for highly variable DNA sequences and for which experimental success requires attention to many interacting constraints.
Contribution: Designed and developed scalable scientific algorithm for primer design that included recursive generation of combinatorial bio-barcodes of specified length with design constraints and dimer risk filtration among the generated primer constructs in C and Perl.
Results: Primer design tool (v1.0) was included among the HIV analysis tools (current tool (v2.0) is at tinyurl.com/yd5hajbc).
BMCbio'13

Los Alamos National Laboratory
Los Alamos, NM

REDESIGN OF COMPUTING ARCHITECTURE TO IMPROVE ANALYSIS EFFICIENCY — 05/2010–12/2011

Purpose: To redesign scientific tools in order to ensure high performance and minimize compute time and file system usage.
Contribution: Designed and deployed five scientific tools using a Model-View-Controller (MVC) framework and web services using XML-RPC on the MVC model provided by Perl Catalyst and object oriented Moose libraries.
Results: The five tools were successfully deployed with an improvement of 35% in performance and 50% in file-system usage.

Rochester Institute of Technology
Rochester, NY

MASTERS THESIS: COMPRESSION AND CACHING IN DISTRIBUTED FILE SYSTEM — 05/2009–06/2010

Purpose: To perform research on compression and caching algorithms to improve data fetch time in a distributed system.
Contribution & Results: Implemented a distributed system using the Java NIO framework and reduced data and file fetch time by 14%.

Los Alamos National Laboratory
Los Alamos, NM

TREE VIEWER, PRUNER, AND DECORATOR — 02/2009–04/2010

Purpose: To build tools that automate the selection and annotation of influenza genetic data by making the correct trade-off between speed and simplicity on the one hand and control over quality and contents of the data set on the other.
Contribution: Designed and developed the tree pruner and decorator tools to perform this selection and annotation for Influenza Sequence Database (ISD). This project was based on the open source project Archaeopteryx using Java Applets, AJAX, and REST web services with the JSON and phyloXML data formats.
Results: Pruner and Decorator tools were made available among influenza analysis tools and were also made open source. (**BMCbio'11**)

Los Alamos National Laboratory
Los Alamos, NM

DATABASE AND WEB ARCHITECTURE DEVELOPMENT — 07/2008–04/2010

Purpose: Design a schema to accommodate millions of records in ISD and develop a website over ISD to serve influenza analysis tools.
Contribution & Results: Designed a new schema in PostgreSQL. Also, developed a website over ISD using Perl, Mason Perl, HTML, XML, Java Scripts and SQL. Further, redesign of the website using jQuery and AJAX request objects yielded 23% better performance.