

TAIMOOR AKHTAR

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EDUCATION

Cornell University, Graduate School

Doctor of Philosophy (Ph.D.) in Civil & Environmental Engineering (in residence 2008-2012) 2015

Major: Environmental and Water Resources Systems Engineering

Minors: 1) Environmental Fluid Mechanics and Hydrology

2) Applied Probability and Statistics

Cornell University, Graduate School

2007-2008

Master of Engineering in Operations Research and Information Engineering

Lahore University of Management Sciences

2000-2004

Bachelor of Science (Honors)

Computer Science (Major), Mathematics (Minor)

RESEARCH AND PROFESSIONAL EXPERIENCE

University of Guelph – School of Engineering

2019-present

Senior Research Fellow

As part of a diverse team of researchers and industry professionals, I am working on development of computer simulation models, parallel optimization & machine learning algorithms and web-based decision support tools (e.g., <https://hydra-water.shinyapps.io/APWS/>) for sustainable environmental and water resource management in Canada and the Asia Pacific region. My contribution in this regard is geared towards i) development of parallel Multi-objective modelling frameworks for a) calibrating complex hydrologic models and b) deducing agricultural management strategies to reduce phosphorus loads into the Great Lakes and ii) development and dissemination of environmental datasets, systems models and machine learning algorithms for hydrological forecasting, reservoir planning and sustainable water management environmental policy decision support. A significant focus of my research is on using parallel optimization, data science and visual analytics to effectively communicate technical research findings to decision makers, for active decision support. I also provide core support to my academic supervisor and research team in technology management, data management and research grant application writing.

National University of Singapore - Environmental Research Institute

2015-2019

Research Fellow - Energy and Environmental Sustainability for Megacities (E2S2)

Researched the application of efficient Multi-objective optimization algorithms, machine learning methods and high performance computing to complex and computationally expensive problems. Application problems included calibration of computationally expensive watershed models & lake water quality models, hyperparameter optimization of Deep Neural Networks, and data-driven prediction of algal blooms. Also contributed strongly to overall management of my supervisor's research projects and research team. Overall job responsibilities included scientific research, mentoring and supervision of Ph.D. students, research proposal writing, project management and design & development of teaching materials for supervisor (Prof. Christine Shoemaker).

Hydra Consulting Services, Lahore-Pakistan

2015

Co-founder and Director, Water Practice

As head of the Water Practice my job was to guide the water team at Hydra in development of a Knowledge platform for integrated management of the water, energy and food nexus. I was responsible for heading the water team's research, consulting and technology practices, where we incorporated the amalgamation of data, Decision Support Systems (DSS) and analytics for development of integrated solutions to water resources management problems.

Water Resources Division (NESPAK), Lahore-Pakistan

2015

Lead Modeler for Development of River Basin Model for Punjab Irrigation System Operations

Water Resources Systems Lead Modeller for the project: "Development of Water Resources Management Information System (WRMIS) and Decision Support System (DSS) for Efficient Irrigation Water Management in Punjab". My specific work scope in the project was to lead the modelling team in: i) development of a network optimization / river basin model for determination (in accordance with the Provincial Water Apportionment Accord 1991) of seasonal and 10-daily canal water entitlements for the Punjab province; ii) development of a river routing and operations model for equitable daily canal operations within the Punjab Irrigation System; and iii) development of a modelling methodology for preparation of seasonal canal rotation and operation plans up to tertiary level. A pre-requisite for the modelling exercise was an in-depth understanding of the prevalent canal planning, regulation and operation mechanism adopted by the irrigation department.

Water Resources Division (NESPAK), Lahore-Pakistan

2013-2014

Project Engineer for Water Capacity Building Project of Indus River System Authority

Worked on the project: "Improvement of Water Resources Management of Indus Basin to Enhance Capacity Building of Indus River Basin System Authority (IRSA)". The project envisioned a review of the flow measurement system employed at key diversion sites within the Indus Basin System in order to update (if needed) stage-discharge relationships for estimating flows. The project also included a snowmelt and glacial melt run-off modelling component for predicting inflows into the irrigation system from the upper reaches of Indus, and for climate change impact assessment within the Indus Basin. My specific work was focused on collection of data (on-site) from all diversion sites, review of stage-discharge relationships with the objective of increasing confidence of provincial stakeholders in the existing / updated flow monitoring system, and understanding of the snowmelt run-off model being developed by NESPAK's sub-consultant, i.e., AHT Group, Germany. The project was a key ingredient of implementing the vision of Integrated Water Resource Management (IWRM) within the Indus Basin of Pakistan.

Water Resources Division (NESPAK), Lahore-Pakistan

2013-2014

Hydrological Analyst for Biodiversity Scoping Assessment of Gulpur Hydropower Project

Performed a comprehensive hydrological analysis for the Gulpur Hydropower Project (GHP) area to assist in assessment of the environmental impacts of the project on Poonch River in Azad Jammu & Kashmir (AJK). The Wildlife and Fisheries Department of Government of AJK have declared Poonch River, for its full length in AJK, as a national park. My specific input in the analysis pertained to development of 'with project' flow forecasts at key environmental flow sites of Poonch River. The flow forecasts were used in environmental impact assessment of GHP on the Poonch river catchment.

Water Resources Division (NESPAK), Lahore-Pakistan

2012-2013

Integrated Water Resources Systems Modeler

Worked on development of a hydro-economic Decision Support System for integrated management of the Indus Basin Irrigation System. The work scope incorporated improvement of the Indus Basin Model Revised (IBMR), development of a groundwater modelling component for IBMR, and coupling of the model with a web-based decision support platform. IBMR is a non-linear network optimization model and a planning tool for analysing alternate water management policies within the Indus Basin Irrigation System

(IBIS). The tool encapsulates hydro-economic modelling, agro-economic modelling, and river systems modelling to devise optimal water distribution and agricultural land use strategies. Specifically worked on 1) model development in GAMS, 2) calibration of hydrological routing coefficients via statistical and data analysis, analysis of groundwater-surface water interactions, rainfall-runoff analysis, optimization and bootstrapping, 3) development of a post-optimization groundwater balance simulation component and 3) development of a network flow only sub-model for use by the Indus River System Authority (IRSA) for equitable provincial water entitlement estimation and hydropower benefit maximization.

Cornell University, School of Civil and Environmental Engineering 2008-2012
Fulbright Fellow / Graduate Research Assistant

Research on devising computationally efficient multi objective optimization techniques for application in water resources decision analysis, groundwater remediation and management, surface water quality management, agricultural land management, and watershed model calibration.

Cornell University, Applied Operations Research Project 2007-2008
Project Consultant, Xerox Technical Services

Worked in conjunction with Xerox management to determine optimal human resource allocation in the services department. Devised a model for scheduling of the technical workforce at Xerox; developed using optimization techniques and simulation modeling, as part of Master of Engineering consulting project.

TEACHING EXPERIENCE

University of Guelph Fall 2019-Ongoing
*Sessional Instructor, CIS*2460: Modelling of Computer Systems*

Instructor for Computer Science undergraduate course on stochastic simulation. Created a student-centric, multi-dimensional (i.e., concurrent to core UDL principles) and skill-development oriented course with interactive lectures, assignments, lab activities, examinations and a simulation design project. Course topics include distribution fitting, interval estimation, stochastic modeling, discrete-event simulation, random number generation, model validation, output analysis, stochastic optimization and model development in R; with a specialized focus on simulation applications in the fields of Computing, Resource Management and Environmental Science.

Habib University 2019
Guest Lecturer, SCI 101: Introduction to Sustainability

Designed and delivered workshops, lectures and in-class analytical & group activities, pertaining to the water systems module of the course. (See https://docs.google.com/forms/d/e/1FAIpQLSe-XafFfra5qBJ_JZrS_E_NgSHrlu-YNUyhrzuiNVDC63Cew/viewanalytics for student feedback.)

National University of Singapore 2016-2018
Guest Lecturer, IE6511: Surrogate and Metaheuristic Global Optimization

Delivered multiple guest lectures for IE6511 and also provided assistance in design of lectures, homework assignments and exams.

Cornell University 2010-2011
Guest Lecturer, CEE 5290: Heuristic Methods for Optimization

Lahore University of Management Sciences 2003-2004
Teaching Assistant – Multiple Courses

Taught tutorial sessions and assisted instructors in designing and grading tests and homework; courses assigned: Linear Algebra and Electromagnetics.

INTERESTED IN

Developing efficient parallel single & multi objective optimization algorithms and frameworks for application to computationally expensive hydrologic model calibration problems, watershed management problems, lake water quality models and other complex simulation-optimization problems.

Applying novel machine learning and statistical algorithms to spatio-temporal environmental forecasting, big time-series data management (e.g., gap filling, failure detection, extreme-event detection etc.), sensor network design and management, model calibration & uncertainty quantification, and water sector policy analysis.

Creating interactive visual analytics and multi-criteria decision support systems for water resource management and decision-making under uncertainty.

Designing and delivering innovative courses and environments to facilitate student learning and skills development, with optimization methods, applied stochastic processes and environmental decision analytics as focus areas.

PUBLICATIONS

Peer-Reviewed Journal Articles

1. Krityakierne, T., **T. Akhtar** and C.A. Shoemaker. (2016) Parallel Surrogate Global Optimization with Pareto Center Selection for Computationally Expensive Single Objective Problems. *Journal of Global Optimization*, 66(3), pp 417-437.
2. **Akhtar, T.** and C.A. Shoemaker. (2016) Multi-objective Optimization of Computationally Expensive Multi-Modal Functions with RBF Surrogates and Multi-Rule Selection. *Journal of Global Optimization*, 64(1), pp 17-32.

Peer-Reviewed Conference Papers

1. McPherson, M. and **T. Akhtar**. (2019) Introducing a flexible platform for modelling energy systems integration. *In: 18th Wind Integration Workshop Proceedings*.
2. **Akhtar, T.**, C.A. Shoemaker and Wenyu Wang. (2019) Surrogate Many Objective Optimization: Combining Evolutionary Search, ϵ -dominance and Connected Restarts. *In: Le Thi H., Le H., Pham Dinh T. (eds) Optimization of Complex Systems: Theory, Models, Algorithms and Applications. WCGO 2019*. Advances in Intelligent Systems and Computing, vol 991. Springer, Cham.
3. **Akhtar, T.** and C.A. Shoemaker. (2019) SOP-Hybrid: A Parallel Surrogate-based Candidate Search Algorithm for Expensive Optimization on Large Parallel Clusters. *In: Le Thi H., Le H., Pham Dinh T. (eds) Optimization of Complex Systems: Theory, Models, Algorithms and Applications. WCGO 2019*. Advances in Intelligent Systems and Computing, vol 991. Springer, Cham.
4. **Akhtar, T.** and C.A. Shoemaker. (2019) Combining Local Surrogates and Adaptive Restarts for Global Optimization of Moderately Expensive Functions. *AIP Conference Proceedings*, 2070, 020048.
5. Shoemaker, C.A, and **T. Akhtar**. (2019) An Adaptive Population-based Candidate Search Algorithm with Surrogates for Global Multi Objective Optimization of Expensive Functions. *AIP Conference Proceedings*, 2070, 020047.

6. Ilija Ilievski, I., **T. Akhtar**, J. Feng and C.A Shoemaker. (2017) Efficient Hyperparameter Optimization of Deep Learning Algorithms Using Deterministic RBF Surrogates. *31st AAAI Conference on Artificial Intelligence*.

Journal and Conference Papers in Review and Revision

1. Ghimire, U., **T. Akhtar**, N. Shrestha, and P. Daggupati. Development of Asia Pacific Weather Statistics (APWS) dataset for use in Soil and Water Assessment Tool (SWAT) simulations. (In review) *Earth System Science Data (ESSD)*. <https://doi.org/10.5194/essd-2019-178>
2. **Akhtar, T.** and C.A. Shoemaker. Bounded Multi Objective Parameter Estimation of Computationally Expensive Watershed Models with Surrogate & Evolutionary Algorithms. (In revision) *Water Resources Research*.
3. Wang, W., **T. Akhtar** and C.A. Shoemaker. Integrating ϵ -Dominance and RBF Surrogate Optimization for Solving Computationally Expensive Many Objective Optimization Problems. (In review) *Journal of Global Optimization*.
4. Xia, W., C.A. Shoemaker, **T. Akhtar** and M. Nguyen. Efficient Parallel Surrogate Optimization Algorithm and Framework for Calibration of Computationally Expensive 3-D Hydrodynamic Lake PDE Models Using Temperature and/or Velocity Data. (In revision) *Environmental Modelling & Software*.

Papers and Book Chapters in Preparation

1. **Akhtar, T.**, H. Khan and D. Mustafa. Water Security in Pakistan: Availability, accessibility and utilization. In M. A. Watto and S. Bashir (Eds.) *Pakistan's water outlook: issues and impacts*, World Water Resources. (In prep.). Springer International Publishing.
2. **Akhtar, T.**, H. Mushtaq and M.Z. Hashmi. Using standard indices for assessment of meteorological and hydrological droughts in Pakistan. *Hydrology and Earth System Sciences (HESS)*.
3. **Akhtar, T.** and C.A. Shoemaker. Efficient Multi-Objective Optimization through Parallel Surrogate-Assisted Local Candidate Search: MOPLS. (In prep.) *INFORMS Journal on Computing*.
4. **Akhtar, T.** and C.A. Shoemaker. The Dynamically Dimensioned Evolutionary Search (DDES) Algorithm for Parallel Simulation-Optimization of Water Resource Models on Supercomputing Clusters. (In prep.) *Advances in Water Resources*.

CONFERENCE PRESENTATIONS

1. Title: "An Efficient Surrogate Multi-Objective Framework for Parameter Estimation of Computationally Expensive Hydrologic Models". Presented at American Geophysical Union Fall Meeting, Dec 2018 (Poster Presentation). Co-Author(s): Christine Shoemaker.
2. Title: "Efficient Calibration of Computationally Expensive SWAT Watershed Models with a Parallel Surrogate Optimization Algorithm: SOP-Hybrid". Presented at European Geophysical Union General Assembly (Oral Presentation), April 2018. Co-Author(s): Christine Shoemaker.
3. Title: "Efficient Multi Objective Watershed Model Calibration Using a Synchronous Global Surrogate Algorithm". Presented at the 7th International Conference on High Performance Scientific Computing (Oral Presentation), Mar 2018. Co-Author(s): Christine Shoemaker.
4. Title: "Parallel Pareto Ranking Dynamically Dimensioned Search (PR-DDS) Algorithm for Efficient Parameter Estimation of Computationally Expensive Watershed Models". Presented at International

Perspective on Water Resources and the Environment 2017 – EWRI - ASCE (Oral Presentation), Jan 2017. Co-Author(s): Christine Shoemaker.

5. Title: “Understanding Model Uncertainty Through Multi Objective Parameter Estimation of Computationally Expensive Watershed Models with Surrogate Algorithms and the Distributed Cardinality Index”. Presented at World Environmental and Water Resources Congress (Oral Presentation), May 2016. Co-Author(s): Christine Shoemaker.
6. Title: “Parameter Estimation of Computationally Expensive Watershed Models Through Efficient Multi-objective Optimization and Interactive Decision Analytics”. Presented at European Geophysical Union General Assembly (Oral Presentation), April 2016. Co-Author(s): Christine Shoemaker.
7. Title: “Multi-objective Optimization for Calibration and Efficient Uncertainty Analysis of Computationally Expensive Watershed Models”. Presented at American Geophysical Union Fall Meeting, Dec 2011 (Poster Presentation). Co-Author(s): Christine Shoemaker.
8. Title: “Multi-objective Optimization of Computationally Expensive Problems”. Presented at The Inst. for Oper. Res. and Mgmt. Sciences (INFORMS), Nov 2011. Co-Author(s): Christine Shoemaker.
9. Title: “Efficient Automatic Watershed Model Calibration Through Multi-Objective Optimization with Function Approximation”. Presented at World Environmental and Water Resources Congress (Conference Presentation), May 2011. Co-Author(s): Christine Shoemaker.
10. Title: “Multi-objective optimization with function approximation including application to computationally expensive groundwater remediation design”. Presented at American Geophysical Union Fall Meeting, Dec 2009 (Poster Presentation). Co-Author(s): Christine Shoemaker.

MISCELLANEOUS ARTICLES

1. **Akhtar, T.** “Talk policy, not dams”. *Dawn*, July 01, 2018. Retrieved from: <https://www.dawn.com/news/1417218/talk-policy-not-dams>.
2. **Akhtar, T.** “Water Management”. *Dawn*, Sep 28, 2018. Retrieved from: <https://www.dawn.com/news/1435425/water-management>.
3. **Akhtar, T.** “Bhasha dam and Pakistan’s water crisis”. *The Third Pole*, Oct 18, 2018. Retrieved from: <https://www.dawn.com/news/1440207/bhasha-dam-and-pakistans-water-crisis>.
4. **Akhtar, T.** and M. F. Ismail. “The Groundwater Gap”. *SouthAsia Magazine*, Nov 2018. Retrieved from: <http://www.southasia.com.pk/sa-1118/the-ground-water-gap.html>.
5. **Akhtar, T.** “Rationalising water”. *Dawn*, Nov 18, 2018. Retrieved from: <https://www.dawn.com/news/1446332/rationalising-water>.
6. Yang, Y.E., C. Ringler, C. Brown, G. Alam, A.F. Khan, **T. Akhtar** and K. Mehmood. (2014) Intersectoral Water Allocation in the Indus Basin-Under Different Management Policies. *International Food Policy Research Institute (IFPRI)*. PSSP Working Paper 24, Washington, D.C. Available at: <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128682>

PROFESSIONAL ACTIVITIES

Reviewer for *Journal of Water Resources Planning and Management, Environmental Modelling and Software, Water Resources Research, Swarm and Evolutionary Computation.*

HONORS AND AWARDS

Fulbright Scholar - Candidate for 2007 Fulbright / USAID Masters Fellowship Program
HEC/Fulbright Scholar - Candidate for 2008 Fulbright / HEC PhD Fellowship Program
Recipient of Ministry of Science and Technology Scholarship from Government of Pakistan (2001-2004)
Outstanding Student Paper Award (OSPA) – American Geophysical Union Fall Meeting 2009
Certified Modeler for the Indus Basin Model Revised (IBMR-2013)

Special Skills

Coursework: Optimization-I, Heuristic Methods for Optimization, Bayesian Optimization, Risk Analysis & Management, Applied Stochastic Processes, Stochastic Hydrology, Engineering Probability and Statistics, Bayesian Statistics, Monte-Carlo Simulation, Discrete-Event Simulation, High Performance Computing, Hydrology, Water Resource Systems Engineering, Environmental Quality Systems Engineering, Numerical Analysis and Differential Equations, Advanced Numerical Methods for Engineers, Computational Simulation of Flow and Transport in the Environment.

Technical Tools: Python, C/C++, VB, MATLAB, AMPL, GAMS, Java, FORTRAN, ProModel, @Risk Excel, R, Soil and Water Assessment Tool (SWAT), eWater Source, MODSIM, HEC-RAS, Delft3D.

List of Referees

- 1) Christine A. Shoemaker:
Title – Distinguished Professor, Departments of Civil and Environmental Engineering & Industrial and Systems Engineering, National University of Singapore.
Professional Relationship with me – PhD and Post-Doctorate Supervisor.
Contact Emails: shoemaker@nus.edu.sg
- 2) Prasad Daggupati:
Title – Assistant Professor – University of Guelph, School of Engineering
Professional Relationship with me – Current Post-Doctoral Supervisor.
Contact Email: pdaggupa@uoguelph.ca
- 3) Daniel Peter Loucks:
Title – Professor Emeritus – Cornell University (member USA National Academy of Engineering)
Professional Relationship with me – Teacher, Mentor and Professor at Cornell University
Contact Email: DPL3@cornell.edu
- 4) Syed Muhammad Mehr Ali Shah:
Title – Joint Secretary (Water), Ministry of Water and Power, Government of Pakistan
Professional Relationship with me – Professional mentor and supervisor at National Engineering Services Pakistan (NESPAK)
Contact Email: syedmeharali@gmail.com
- 5) Madeleine McPherson:
Title – Assistant Professor – University of Victoria, Department of Civil Engineering
Professional Relationship with me – Research Collaborator.
Contact Email: mmcpherson@uvic.ca