HESSA KHALED AL-THANI

Department of Industrial and Operations Engineering

University of Michigan, Ann Arbor, MI

**PROFESSIONAL PROFILE**

**Contact Information:**

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| Email: | hessakh@umich.edu |
| GitHub: | https://github.com/hessakh |
| LinkedIn: | https://www.linkedin.com/in/hessa-al-thani-5233a874/ |

Website: https://hessakh.github.io/

**Relevant Skills:**

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| Discipline: | Combinatorial Optimization, Approximation Algorithms, Optimization for Data Analytics, Stochastic Optimization |
| Programing Languages: | Python, R, Java, VBA, MATLAB, Julia, AMPL, GAMS |
| Solvers & Packages: | Gurobi, cvx, JuMP, BARON, PyTorch |

**EDUCATION**

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| **University of Michigan, Ann Arbor, MI**  Ph.D., Industrial and Operations Engineering  MSc., Industrial and Operations Engineering  Advisor: Dr. Viswanath Nagarajan  GPA: 3.9/4.0 | May 2025  Dec 2019 |
| **Carnegie Mellon University in Qatar**  B.Sc, Business Administration  Minor: Mathematical Sciences, Ethics  GPA: 3.6/4.0, Total Credits: 230.5 | May 2016 |
| **Carnegie Mellon University, Pittsburgh PA**  Abroad Study | Spring 2015 |

**GRADUATE COURSEWORK**

**Industrial and Operations Engineering Coursework**

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| IOE 510: Linear Programming | IOE 614: Integer Programming |
| IOE 511: Continuous Optimization Methods | IOE 516: Stochastic Processes II |
| IOE 543: Scheduling  EECS 598: Approximation Algorithms | IOE 565: Time Series Analysis |

**Other Coursework**

EECS 572 Randomized Algorithms EECS 586 Algorithms

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| CEE 575 Infrastructure Sensing  EECS 545 Machine Learning | EECS 598 Randomized Numerical Linear Algebra  MATH 571 Numerical Linear Algebra |

**GRADUATE RESEARCH EXPERIENCE**

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| |  |  | | --- | --- | | **Stochastic Query Minimization**  *Working paper*  The stochastic query-minimization problem considers a set of bounded random variables, each of which can be probed to determine its realized value. We are interested in determining the minimum (or maximum) value of these random variables upto some precision, while minimizing the number of queries. This is an abstract model that has applications in database network optimization where the intervals are constructed using cached values and the owner of the database wants to identify the bottleneck node with the minimum number of queries to the precise bandwidth. We provide a 4-approximate policy for this problem.  **Minimum Cost Adaptive Submodular Cover**  *Submitted 2024*  We extended an existing approximation algorithm on the minimum expected cost to bound the p-th moment of the coverage cost guarantee for the same greedy policy. Adaptive submodular cover is a concept in stochastic optimization and a generalization of the set cover problem. It has applications in active learning, sensor placement, viral marketing and hypothesis identification. The approximation guarantees we present are the best possible up to constant factors (unless P = NP).  **ML Generated Counter examples for the Monotone Hirsch Conjecture**  *Working paper*  The Hirsch conjecture is a bound on the diameter of a polytope and has implications for Linear Programing (LP) theory. The conjecture has been shown to not be true through notable examples in high dimension, the study of such counterexamples sheds light on the complexity of LP algorithms. The monotone Hirsch conjecture is a variant of the Hirsch Conjecture that bounds the monotone combinatorial diameter of a polytope. We develop a recurrent neural network that aims to find new counterexamples based on a fine-tuned reward function and knowledge about the structure of current counter examples.  **Maximum-entropy Sampling Polynomial-time Algorithms**  *Published 2023*  Developed an exact polynomial time algorithm for two cases of sparsity structures in the input of the Maximum-Entropy Sampling Problem (MESP). We also proved a sufficiency condition for when a simple local search algorithm is optimal for when the input is an arrowhead. In addition, we ran a series of experiments on input from real data and constructed inputs to test the performance of each of the algorithms. For one algorithm we showed that we could parallelize some of the work, to get to the exact solution. | January 2024 - Present  September 2023-May 2024  Spring 2023 - Present  March 2020-March 2023 | | **Maximum-entropy Sampling Masked Upper Bound**  *Published 2022*  Analyzed variations of a mask M (a correlation matrix) to see which could minimize the masked upper bound for the Maximum-entropy Sampling Problem. We focused on tridiagonal masks and derived multiple formulas that would allow us to minimize the upper bound by maximizing super and sub-diagonal elements of the mask. We ran experiments on variations of the input C including some from sensor data and some interesting, constructed inputs. | Summer 2020 – March 2021 | | **An R Package for Generating Input for the Maximum-Entropy Sampling**  *Published 2020*  Created an R package that automates the process of generating and validating the input covariance matrix C from the dataset maintained by National Atmospheric Deposition Programs National Trends Network. The R is flexible and transparent and allows users to choose the parameters of the de-seasonalizing and de-trending time-series model that allows the end covariance matrix to be Gaussian and thus valid for the formulation of differential entropy in the MESP. | January 2019-March 2020 | | |
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**CONFERENCE PRESENTATIONS**

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| “*Minimum Cost Adaptive Submodular Cover*”, INFORMS Optimization Society  “Tridiagonal Maximum-entropy Sampling and Tridiagonal Masks.”, INFORMS Optimization Society | March 2024  March 2022 |
| “Tridiagonal Maximum-entropy Sampling and Tridiagonal Masks.*”*, Latin-American Algorithms, Graph and Optimization Symposium | May 2021 |

**PUBLICATIONS**

Al-Thani, H., Cui, Y., & Nagarajan, V. (2022). Minimum Cost Adaptive Submodular Cover. Submitted to Mathematics of Operations Research May 2024

Al-Thani, H., & Lee, J. (2022). Tridiagonal Maximum-Entropy Sampling and Tridiagonal Masks. Discrete Applied Mathematics.

Al-Thani, H., & Lee, J. (2020, September). An R Package for generating covariance matrices for maximum-entropy sampling from precipitation chemistry data. In *SN Operations Research Forum* (Vol. 1, No. 3, pp. 1-21). Springer International Publishing.

Released the R Package for Generating Covariance Matrices for MESP on GitHub: https://github.com/hessakh/MESgenCov

**FELLOWSHIPS AND AWARDS**

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| Michigan Institute of Computational Discovery and Engineering | 2020 |
| Qatar National Research Fund Graduate Research Award  Qatar National Research Fund Graduate Research Award | 2020  2017 |

**INDUSTRY EXPERIENCE**

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| **Qatar Computing Research Institute, Qatar**  Research Intern   * Developed a way to model an extension of the facility location problem with must-link and cannot-link constraints using linear constraints, where previously logical constraints were used. * Coded and tested different phases of the derived algorithm using JuMP and Julia. | Summer 2021 |
| **Qatar Investment Authority, Qatar**  Investment Analyst Intern   * Built the prototype of a risk analysis model that later was implemented and distributed by the IT department at the firm. * Coded a model in VBA the used linear algebra to decompose risk contribution with respect to weight in stock, sub-portfolios, and external factors. * Developed the documentation for the risk analysis model and facilitated the Risk Analysis. Department Manager’s pitch towards making the risk analysis model accessible to all analysts in the company. | Summer 2017 |
| **Netherlands Organization for Applied Scientific Research (TNO), Qatar**  Research Intern   * Created a literature survey on the impact of culture on innovation. * Replicated a quantitative Harvard study on innovative behavior using the researchers at TNO to verify the results of the study. * Developed and submitted a report on the impact of culture on innovation in the GCC and presented the findings to team of researchers that will follow up with the research questions created by the study. | Summer 2016 |
| **PwC, Doha, Qatar**  Deals Intern   * Created a stochastic discounted cash flow model in R and presented on the risk involved with a current valuation. * Assisted the due diligence team in identifying inconsistencies in the client’s own valuation. | Winter 2017 |
| **Maersk Oil, Qatar**  Business Planning Intern   * Used VBA to automate the extraction of relevant information from a drilling schedule. * Created a macro that would calculate revenue given a period of time and monthly oil revenues associated with the drilling schedule. * Set up an excel workbook that could evaluate the NPV of up to 6 drilling schedule options. | August – October 2016 |
| **Qatar Airways, Qatar**  Network Planning Intern   * Studied the profitability of adding three destinations to the Qatar Airways network, one was launched. * Presented two recommendations to the Qatar Airways Vice President of Planning and CPO. | Summer 2015 |
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**TEACHING EXPERIENCE**

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| **Ethics of Leadership Teaching Assistant, Carnegie Mellon University Qatar**  Facilitated discussions on course topics over Twitter  Assisted students in understanding the elements of good argumentation in Ethics | Fall 2015 |
| **Organizational Behavior Teaching Assistant, Carnegie Mellon University Qatar**  Graded papers according to Professor’s criteria  Assisted students in understanding organizational behavior theories as applied in multinational companies | Spring 2014 |

**PROFESSIONAL SERVICE AND AFFILIATIONS**

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| **Institute of Operations Research and Management Sciences (INFORMS), UMICH**  Pro Bono Chair  Facilitated 4 projects and led teams that served community projects that required some facet of the Industrial and Operations Engineering skill set. One recent project has been in working with a tax volunteer organization that needed our help to make their python tax tool more accessible. | 2020-Present |
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**AFFILIATIONS: PREVIOUS**

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| **Carnegie Mellon Business Association**  President  Planned an event that allowed groups of students to set up businesses for three days and then present their profits and experience to a panel of business Professors.  Facilitated an etiquette dinner where students learn about table etiquette and formal business attire.  Organized a university-wide fashion show where students business formal dress and their variation based on industry.  Won the award of most active club for the academic year 2014-2015 | Fall 2018- Spring 2019 |
| **Dreamer’s Club**  Vice-president  Organized workshops and social events for club members.  Facilitated a 50+ person event. | Fall 2014-Spring 2015 |

**ADDITIONAL SERVICE AND OUTREACH**

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| **Student Life Advisory Committee**  Member  Participated in a committee that decided on how a new space in the building would be used. | Winter 2016 |
| **Peer Health Advocate**  Supported the Director of Health & Wellness in creating and organizing events that would raise community awareness on physical and mental health issues. | 2014-2016 |