HESSA KHALED AL-THANI
Department of Industrial and Operations Engineering
University of Michigan, Ann Arbor, MI

PROFESSIONAL PROFILE

Contact Information:

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:

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

University of Michigan, Ann Arbor, MI

Ph.D., Industrial and Operations Engineering	Dec 2024 (Exp.)
MSc., Industrial and Operations Engineering	Dec 2019

Advisor: Dr. Viswanath Nagarajan
GPA: 3.8/4.0

Carnegie Mellon University in Qatar — May 2016

B.Sc, Business Administration
Minor: Mathematical Sciences, Ethics
GPA: 3.6/4.0, Total Credits: 230.5

Carnegie Mellon University, Pittsburgh PA — Spring 2015

Abroad Study

GRADUATE COURSEWORK

Industrial and Operations Engineering Coursework

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

Other Coursework

EECS 572 Randomized Algorithms	EECS 586 Algorithms
CEE 575 Infrastructure Sensing	EECS 598 Randomized Numerical Linear Algebra
EECS 545 Machine Learning	MATH 571 Numerical Linear Algebra

GRADUATE RESEARCH EXPERIENCE

Stochastic Query Minimization — January 2024 – Present
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

September 2023-May 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

Spring 2023 - Present

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

March 2020-March 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.

Maximum-entropy Sampling Masked Upper Bound

Published 2022

Summer 2020 – March 2021

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.

An R Package for Generating Input for the Maximum-Entropy Sampling

Published 2020

January 2019-March 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.

CONFERENCE PRESENTATIONS

"*Minimum Cost Adaptive Submodular Cover*", INFORMS Optimization Society

March 2024

"*Tridiagonal Maximum-entropy Sampling and Tridiagonal Masks.*", INFORMS Optimization Society

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

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

INDUSTRY EXPERIENCE

Qatar Computing Research Institute, Qatar   Summer 2021
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.

Qatar Investment Authority, Qatar   Summer 2017
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.

Netherlands Organization for Applied Scientific Research (TNO), Qatar   Summer 2016
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.

PwC, Doha, Qatar   Winter 2017
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.

Maersk Oil, Qatar Business Planning Intern	August – October 2016

- 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.

Qatar Airways, Qatar Network Planning Intern	Summer 2015

- 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.

TEACHING EXPERIENCE

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

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

AFFILIATIONS: PREVIOUS

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

Student Life Advisory Committee Member	Winter 2016

Participated in a committee that decided on how a new space in the building would be used.

Peer Health Advocate   2014–2016
Supported the Director of Health & Wellness in creating and organizing events that would raise community awareness on physical and mental health issues.