

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

## PROFESSIONAL PROFILE

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### Contact Information:

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### Relevant Skills:

Discipline: Combinatorial Optimization, Approximation Algorithms, Optimization for Data Analytics, Stochastic Optimization  
Programming 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	May 2025
MSc., Industrial and Operations Engineering	Dec 2019
Advisor: Dr. Viswanath Nagarajan	
GPA: 3.9/4.0	

### Carnegie Mellon University in Qatar

B.Sc, Business Administration	May 2016
Minor: Mathematical Sciences, Ethics	
GPA: 3.6/4.0, Total Credits: 230.5	

### Carnegie Mellon University, Pittsburgh PA

Abroad Study	Spring 2015
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## GRADUATE COURSEWORK

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### 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

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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.

January 2024 -  
Present

### **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 Programming (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**

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“*Minimum Cost Adaptive Submodular Cover*”, INFORMS Optimization Society

March 2024

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

March 2022

## 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

<b>Qatar Computing Research Institute, Qatar</b> Research Intern	Summer 2021
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- 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.

<b>Qatar Investment Authority, Qatar</b> Investment Analyst Intern	Summer 2017
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- 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.

<b>Netherlands Organization for Applied Scientific Research (TNO), Qatar</b> Research Intern	Summer 2016
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- 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.

<b>PwC, Doha, Qatar</b> Deals Intern	Winter 2017
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- 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**

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**Ethics of Leadership Teaching Assistant, Carnegie Mellon University Qatar**

Fall 2015

Facilitated discussions on course topics over Twitter

Assisted students in understanding the elements of good argumentation in Ethics

**Organizational Behavior Teaching Assistant, Carnegie Mellon University Qatar**

Spring 2014

Graded papers according to Professor's criteria

Assisted students in understanding organizational behavior theories as applied in multinational companies

**PROFESSIONAL SERVICE AND AFFILIATIONS**

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**Institute of Operations Research and Management Sciences (INFORMS), UMICH**

2020–Present

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.

**AFFILIATIONS: PREVIOUS**

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**Carnegie Mellon Business Association**Fall 2018– Spring  
2019

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

**Dreamer's Club**Fall 2014–Spring  
2015

Vice-president

Organized workshops and social events for club members.

Facilitated a 50+ person event.

**ADDITIONAL SERVICE AND OUTREACH**

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**Student Life Advisory Committee**

Winter 2016

Member

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.