

Elias B. Khalil

CONTACT INFORMATION

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RESEARCH AREAS

discrete optimization, machine learning, integer programming, deep learning

EDUCATION

Georgia Institute of Technology, Atlanta, Georgia, USA

Ph.D. Candidate, *Computational Science & Engineering* **2014 – 2019 (expected)**

- Advisor: [Bistra Dilkina](#)
- Thesis: *Towards Tighter Integration of Machine Learning & Discrete Optimization*
- Committee: [Bistra Dilkina](#), [George Nemhauser](#), [Shabbir Ahmed](#), [Le Song](#), [Tuomas Sandholm](#)
- Minor area: Operations Research (School of Industrial & Systems Engineering)

M.S., *Computer Science* **2012 – 2014**

- Thesis: *Optimizing the Structure of Diffusion Networks: Theory and Algorithms*
- Committee: [Bistra Dilkina](#), [Le Song](#), [Duen Horng \(Polo\) Chau](#)

American University of Beirut (AUB), Beirut, Lebanon

B.S., *Computer Science* **2009 – 2012**

- Final Project: *Optimized Summation of Polynomial Multiplications using Funnel Heaps*
- Dean's Honor List, 2009 – 2011

FELLOWSHIPS

IBM Ph.D. Fellowship (\$30,000) **2017 – 2018**

Awarded to exceptional Ph.D. students in a worldwide competitive process

Marshall D. Williamson Fellowship (\$2,600), Georgia Institute of Technology **2014**

Awarded to the top 2nd year Master's student at the College of Computing

Donald V. Jackson Fellowship (\$1,500), Georgia Institute of Technology **2013**

Awarded to the top 1st year Master's student at the College of Computing

Association Philippe Jabre Fellowship (\$5,000) **2012 – 2013**

Awarded to outstanding students in Lebanon to support graduate education abroad

PAPER & POSTER AWARDS

First Prize, Poster Competition, INFORMS Annual Meeting **2017**

Machine Learning for Integer Programming; Out of over 100 participants in all areas of operations research

Outstanding Poster Award, NemFest Workshop in Celebration of Nemhauser and Nemirovski **2017**

Learning to Run Heuristics in Tree Search; Out of over 20 participants in all areas of optimization

Best Paper Award, NIPS Workshop on Frontiers of Network Analysis **2013**

CUTTINGEDGE: Influence minimization in networks; Out of over 20 participants; As Master's student

PROFESSIONAL EXPERIENCE

Georgia Institute of Technology, Atlanta, Georgia USA

Graduate Research Assistant

August 2014 – Present

IBM Research AI, Yorktown Heights, New York USA

Research Intern – Automated Machine Learning & Data Science

August 2017 – Dec. 2017

IBM Research, Yorktown Heights, New York USA

Research Intern

May 2016 – July 2016

Symantec Corporation, Culver City, California USA

Research Intern, Research Labs

May 2013 – August 2013

CONFERENCE PROCEEDINGS

[1] **Elias B. Khalil**, Amrita Gupta, Bistra Dilkina. (2019). Combinatorial Attacks on Binarized Neural Networks. International Conference on Learning Representations (ICLR). [arXiv:1810.03538 \[cs.LG\]](https://arxiv.org/abs/1810.03538).

[2] **Elias B. Khalil***, Hanjun Dai* (*co-first authors), Yuyu Zhang, Bistra Dilkina, Le Song. (2017). Learning Combinatorial Optimization Algorithms over Graphs. Neural Information Processing Systems (NIPS). **Spotlight presentation, top 5% of submissions.**

[3] Afshar, Ardavan, Joyce C. Ho, Bistra Dilkina, Ioakeim Perros, **Elias B. Khalil**, Li Xiong, and Vaidy Sunderam. (2017). CP-Ortho: An orthogonal tensor factorization framework for spatio-temporal data. Proceedings of the 25th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems. ACM, 2017.

[4] **Elias B. Khalil**, Bistra Dilkina, George Nemhauser, Shabbir Ahmed, Yufen Shao. (2017). Learning to Run Heuristics in Tree Search. Proceedings of the 26th International Joint Conference on Artificial Intelligence (IJCAI).

[5] Fatemeh Nargesian, Udayan Khurana, Horst Samulowitz, **Elias B. Khalil**, Deepak Turaga. (2017). Learning Feature Engineering for Classification. Proceedings of the 26th International Joint Conference on Artificial Intelligence (IJCAI).

[6] Mehrdad Farajtabar, Jiachen Yang, Xiaojing Ye, Huan Xu, Rakshit Trivedi, **Elias B. Khalil**, Shuang Li, Le Song, Hongyuan Zha. (2017) Fake News Mitigation via Point Process Based Intervention. International Conference on Machine Learning (ICML).

[7] **Elias B. Khalil**, Pierre Le Bodic, Le Song, George Nemhauser, Bistra Dilkina. (2016). Learning to Branch in Mixed Integer Programming. 30th AAAI Conference on Artificial Intelligence (AAAI).

[8] **Elias B. Khalil**, Bistra Dilkina, Le Song. (2014). Scalable Diffusion-Aware Optimization of Network Topology. 20th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD).

JOURNAL ARTICLES

[9] Wenwen Zhang, Subhrajit Guhathakurta, **Elias B. Khalil**. (2018). The impact of private autonomous vehicles on vehicle ownership and unoccupied VMT generation. Transportation Research Part C: Emerging Technologies.

[10] Acar Tamersoy, **Elias B. Khalil**, Bo Xie, Stephen Lenkey, Brian Routledge, Duen Horng Chau, Shamkant Navathe. (2014). Large-scale insider trading analysis: patterns and discoveries. *Social Network Analysis and Mining (SNAM)*, 4(1), pp. 1–17.

REFEREED WORKSHOP OR SHORT PAPERS

[11] **Elias B. Khalil**, Bistra Dilkina. (2018). Training Binary Neural Networks with Combinatorial Optimization. Extended Abstract. 15th International Conference on the Integration of Constraint Programming, Artificial Intelligence, and Operations Research (**CPAIOR**).

[12] Udayan Khurana, Fatemeh Nargesian, Horst Samulowitz, **Elias B. Khalil**, Deepak Turaga. (2016). Automating Feature Engineering. Workshop on Artificial Intelligence for Data Science at NIPS.

[13] **Elias B. Khalil**. (2016). Machine Learning for Integer Programming. Proceedings of the Doctoral Consortium at the Twenty-Fifth International Joint Conference on Artificial Intelligence (**IJCAI**).

[14] Sucheta Soundarajan, Acar Tamersoy, **Elias B. Khalil**, Tina Eliassi-Rad, Duen Horng Chau, Brian Gallagher, Kevin Roundy. (2016). Generating Graph Snapshots from Streaming Edge Data (poster paper). 25th International World Wide Web Conference (**WWW**).

[15] **Elias B. Khalil**, Bistra Dilkina, Le Song. (2013). CUTTINGEDGE: Influence minimization in networks. Workshop on Frontiers of Network Analysis: Methods, Models, and Applications at (**NIPS**). **Best Paper award**.

SELECTED TALKS

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| 1. INFORMS Annual Meeting | Phoenix, USA, November 2018 |
| 2. International Symposium on Mathematical Programming | Bordeaux, France, July 2018 |
| 3. CPAIOR Masterclass (Invited Tutorial Speaker) | Delf, The Netherlands, June 2018 |
| 4. NIPS (Spotlight talk, Travel award) | Long Beach, USA, December 2017 |
| 5. INFORMS Annual Meeting | Houston, USA, November 2017 |
| 6. IJCAI (Travel award) | Melbourne, Australia, August 2017 |
| 7. INFORMS Annual Meeting | Nashville, USA, November 2016 |
| 8. IBM Research | Yorktown Heights, USA, June 2016 |
| 9. INFORMS Optimization Society Conference | Princeton, USA, March 2016 |
| 10. AAAI Conference on Artificial Intelligence (Travel award) | Phoenix, USA, February 2016 |
| 11. International Symposium on Mathematical Programming | Pittsburgh, USA, July 2015 |
| 12. Knowledge Discovery & Data Mining (KDD) | New York City, USA, August 2014 |

SELECTED POSTERS

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| 1. Theoretical Foundation of Deep Learning workshop | Atlanta, USA, October 2018 |
| 2. INFORMS Annual Meeting (Best Poster) | Houston, USA, November 2017 |
| 3. Doctoral Consortium on Computational Sustainability | Los Angeles, USA, July 2017 |
| 4. NemFest Workshop in Celebration of Nemhauser and Nemirovski (Best Poster) | Atlanta, USA, May 2017 |
| 5. Doctoral Consortium at IJCAI | New York City, USA, July 2016 |
| 6. Mixed Integer Programming Workshop (Travel award) | Chicago, USA, June 2015 |

7. Georgia Tech Research and Innovation Conference (**Best Poster**) Atlanta, USA, Feb. **2015**
 8. NIPS Workshop: Frontiers of Network Analysis (**Best Paper**) Lake Tahoe, USA, Dec. **2013**

TRAVEL AWARDS

CPAIOR (\$250)	2018
NIPS (\$800)	2017
IJCAI (\$1,000)	2016
AAAI (\$125)	2016
Mixed Integer Programming Workshop (\$500)	2015
Georgia Tech Career, Research and Innovation Conference (\$1,500; twice)	2015, 2016

TEACHING EXPERIENCE

Tutorial Presenter **2018**

CPAIOR '18 Master Class on Machine Learning for Discrete Optimization
 Delft, The Netherlands

Teaching Assistant **2014, 2018**

Computational Science & Engineering Algorithms (CSE 6140)

Georgia Institute of Technology, Atlanta, Georgia USA

- Fall 2018: Prof. Umit Catalyurek, 160 students
- Fall 2014: Prof. Bistra Dilkina, 90 students
- Gave multiple full lectures on approximation algorithms, local search, submodular optimization
- Helped design course assignments and projects

Guest Lecturer **2018**

Topics in Discrete Optimization and Learning (CSCI 699), Spring 2018

University of Southern California, Los Angeles, California, USA

- Contributed to the design of the course curriculum
- Gave a lecture on recent advances in deep reinforcement learning for optimization

Mentor **2013, 2015**

Georgia Institute of Technology, Atlanta, Georgia USA

- Sachin Grover: Undergraduate in Computer Science at IIT, Jodhpur
 Summer research internship, Summer 2015: "Online Learning in Branch-and-Bound"
 Currently Ph.D. Student in Computer Science, Carnegie Mellon University
- Samuel Clarke: Undergraduate in Computer Science at Georgia Tech
 Independent research under Prof. Polo Chau, 2013: "Graph Mining with SQLite"
 Currently M.S. Student in Robotics, Carnegie Mellon University

ACADEMIC SERVICE

Program Committee member

ICLR: International Conference on Learning Representations	2019
AISTATS: International Conference on Artificial Intelligence and Statistics	2019
AAAI Conference on Artificial Intelligence	2017, 2018
NIPS: Neural Information Processing Systems (Top 30% of reviewers in 2018)	2017, 2018
ICML: International Conference on Machine Learning	2018

Journal Reviewer

Operations Research

INFORMS Journal on Computing

INFORMS Journal on Optimization

Annals of Operations Research

Computers & Operations Research

Journal of Machine Learning Research (JMLR)

IEEE Transactions on Knowledge and Data Engineering (TKDE)

Conference Reviewer

AAAI (2015, 2016), Constraint Programming (2016), IJCAI (2016), KDD (2015, 2016)

Vice President, Graduate Student Association

Computational Science & Engineering, Georgia Tech

2016 – 2018

- Organized [HotCSE student seminar](#) (25 talks)
- Organized student interviews with 15 faculty candidates
- Led CSE soccer teams in four Georgia Tech intramurals tournaments

GRANT WRITING EXPERIENCE

Office of Naval Research: *Integrating Machine Learning and Integer Programming*

2018

Assisted Bistra Dilkina, George Nemhauser, Sebastian Pokutta.

Submitted in September 2018 ([call](#)).

ExxonMobil: *Leveraging Machine Learning and High-Performance Computing for Mixed Integer Programming* 2016

Assisted Shabbir Ahmed, David Bader, Bistra Dilkina, George Nemhauser.

Granted, Dec. 2016 – Dec. 2017 (\$405,000).

PATENTS

Systems and Methods for Adjusting Suspiciousness Scores in Event-Correlation Graphs

2015

While at Symantec. Filed in 2013, Granted in 2015. US9148441 B1

Systems and Methods for Using Event-Correlation Graphs to Detect Attacks on Computing Systems

2015

While at Symantec. Filed in 2013, Granted in 2015. US9141790 B2

LANGUAGES

Fluent in Arabic, English and French

REFERENCES

Bistra Dilkina

WiSE Gabilan Assistant Professor
Department of Computer Science
University of Southern California, Los Angeles, California, USA
Email: dilkina@usc.edu

George Nemhauser

A. Russell Chandler III Chair and Institute Professor
School of Industrial & Systems Engineering
Georgia Institute of Technology, Atlanta, Georgia USA
Email: gn3@gatech.edu

Tuomas Sandholm

Angel Jordan Professor of Computer Science
Computer Science Department
Carnegie Mellon University, Pittsburgh, PA USA
Email for recommendation letters: jpacker@andrew.cmu.edu, Jessica Packer (Assistant to T. Sandholm)
Email: sandholm@cs.cmu.edu

Shabbir Ahmed

Anderson-Interface Chair and Professor
School of Industrial & Systems Engineering
Georgia Institute of Technology, Atlanta, Georgia, USA
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Andrea Lodi

Canada Excellence Research Chair in Data Science for Real-Time Decision-Making and Professor
Department of Mathematical and Industrial Engineering
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