Elias B. Khalil

Contact Information

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Research Areas

artificial intelligence, machine learning, operations research, discrete optimization, deep learning

Professional Experience

University of Toronto, Toronto, Canada
Assistant Professor, Department of Mechanical & Industrial Engineering — **Starting July 2020**
Faculty Affiliate, Vector Institute

Polytechnique Montreal & IVADO, Montreal, Canada
IVADO Postdoctoral Scholar — **August 2019 – July 2020**

Georgia Institute of Technology, Atlanta, Georgia USA
Graduate Research Assistant — **August 2014 – May 2019**

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**

Education

Georgia Institute of Technology, Atlanta, Georgia, USA

Ph.D. in Computational Science & Engineering — **2014 – 2019**
- 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. in 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. in 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

Conference Papers

[1] **Elias B. Khalil**, Amrita Gupta, Bistra Dilkina. (2019). Combinatorial Attacks on Binarized Neural Networks. International Conference on Learning Representations (ICLR).

[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 Papers

[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

1. (upcoming) Canadian Operational Research Society Annual Conference — Toronto, USA, June **2021**
2. (upcoming) Mixed Integer Programming Workshop — Rutgers, USA, May **2021**
3. (upcoming) Fujitsu Co-Creation Research Laboratory Monthly Seminar — Toronto, April **2020**
4. Conference on Data Science and Optimization – Fields Institute — Toronto, November **2019**
5. Waterloo ML + Security + Verification Workshop — Waterloo, Canada, August **2019**
6. Machine Learning in Science and Engineering (MLSE) — Atlanta, USA, June **2019**
7. Duke University — Durham, USA, March **2019**
8. University of Waterloo — Waterloo, Canada, March **2019**
9. Northeastern University — Boston, USA, February **2019**
10. University of Toronto — Toronto, Canada, January **2019**
11. INFORMS Annual Meeting — Phoenix, USA, November **2018**
12. International Symposium on Mathematical Programming — Bordeaux, France, July **2018**
13. CPAIOR Masterclass (**Invited Tutorial Speaker**) — Delf, The Netherlands, June **2018**

14. NIPS (**Spotlight talk, Travel award**) Long Beach, USA, December **2017**
15. INFORMS Annual Meeting Houston, USA, November **2017**
16. IJCAI (**Travel award**) Melbourne, Australia, August **2017**
17. INFORMS Annual Meeting Nashville, USA, November **2016**
18. INFORMS Optimization Society Conference Princeton, USA, March **2016**
19. AAAI Conference on Artifical Intelligence (**Travel award**) Phoenix, USA, February **2016**
20. International Symposium on Mathematical Programming Pittsburgh, USA, July **2015**
21. Knowledge Discovery & Data Mining (KDD) New York City, USA, August **2014**

Selected Posters

1. International Conference on Learning Representations New Orleans, USA, May **2019**
2. Theoretical Foundation of Deep Learning workshop Atlanta, USA, October **2018**
3. INFORMS Annual Meeting (**Best Poster**) Houston, USA, November **2017**
4. Doctoral Consortium on Computational Sustainability Los Angeles, USA, July **2017**
5. NemFest Workshop in Celebration of Nemhauser and Nemirovski (**Best Poster**) Atlanta, USA, May **2017**
6. Doctoral Consortium at IJCAI New York City, USA, July **2016**
7. Mixed Integer Programming Workshop (**Travel award**) Chicago, USA, June **2015**
8. Georgia Tech Research and Innovation Conference (**Best Poster**) Atlanta, USA, Feb. **2015**
9. NIPS Workshop: Frontiers of Network Analysis (**Best Paper**) Lake Tahoe, USA, Dec. **2013**

Grant Funding

NSERC Discovery Grant **2020-2025**

Title: “New Machine Learning Approaches for Discrete Optimization"
Total: CAD132,500 over 5 years

Compute Canada, Resources for Research Groups **2020-2021**

Title: “Deep Learning for Operations Research with Social Good Applications"
Total: Computing resources valued at CAD27,317

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

(upcoming) ISCO Spring School on Data Science, Machine Learning & Optimization **2021**
(upcoming) IJCAI-PRICAI 2020, Tutorial on Machine Learning for Combinatorial Optimization **2020**
Machine Learning Bootcamp for Engineering Faculty at the University of Toronto **2019**
CPAIOR '18 Master Class on Machine Learning for Discrete Optimization **2018**

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

Student Advising

University of Toronto, research group **starting September 2020**
- Bo Tang, Ph.D. student
- Oscar Guaje, Ph.D. student
- Rahul Patel, Ph.D. student
- Jacob Mosseri, MASc. student

Polytechnique Montreal **2020**
- Antonia Chmiela: Graduate student at TU Berlin
  4-month research internship on "Learning-Driven Scheduling of Heuristics in Branch-and-Bound"

Georgia Institute of Technology **2013, 2015**
- 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

Conference organization

Co-founder and organizer, Discrete Optimization Talks Seminar Series **2020**
Cluster co-chair for AI & ML, Canadian Operations Research Society (CORS) **2020–2021**
Spring School co-organizer, International Symposium on Combinatorial Optimization (ISCO) **2020–2021**
Session chair, INFORMS Annual Meeting **2019, 2020**

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, 2020**
NIPS: Neural Information Processing Systems **(Top 400 reviewers in 2019, Top 30% in 2018)** **2017–2019**
ICML: International Conference on Machine Learning **2018**
IJCAI: International Joint Conference on Artificial Intelligence **2020**

Journal Reviewer
Operations Research
Management Science
INFORMS Journal on Computing
INFORMS Journal on Optimization
Annals of Operations Research
European Journal of Operational 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

Other
Selection committee member, IVADO Undergraduate Research Scholarships **2020**

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