

Edith Law

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CURRENT EMPLOYMENT

University of Waterloo (Waterloo, ON)

Associate Professor, David R. Cheriton School of Computer Science (since July 2020)

Assistant Professor, David R. Cheriton School of Computer Science (2014-2020)

* From November 1, 2016 – September 1, 2017, I was on a 10-month maternity leave.

EDUCATION AND PROFESSIONAL PREPARATION

Harvard University (Cambridge, MA) (2012-2014)

Postdoctoral Researcher, School of Engineering and Applied Sciences

Carnegie Mellon University (Pittsburgh, PA) (2006-2012)

PhD in Machine Learning (2012)

Advisors: Luis von Ahn (Computer Science) and Tom Mitchell (Machine Learning)

Dissertation: *Attribute Learning using Joint Human and Machine Computation*

McGill University (Montreal, QC) (2003-2005)

M.Sc. in Computer Science (2005)

Advisor: Doina Precup

Dissertation: *Risk-Directed Exploration in Reinforcement Learning*

University of British Columbia (Vancouver, BC) (1995-2000)

B.Sc. in Computer Science (2000)

Advisor: Maria Klawe

MAJOR HONORS AND AWARDS

Best paper award at ACM CSCW Conference (2018)

Best paper honorable mention award at ACM CHI Conference (2016)

Harvard Center for Research on Computation and Society Fellowship (2012-2014)

AAMAS Challenges and Visions Track, Best Paper Second Prize (2013)

Best paper honorable mention award at ACM CHI Conference (2012)

FQRNT Postdoctoral Fellowship (Declined) (2012-2014)

Microsoft Graduate Research Fellowship (2009-2011)

Best paper honorable mention award at ACM CHI Conference (2009)

Robin Popplestone Fellowship, UMass Amherst (Declined) (2006)

NSERC Postgraduate Scholarship PGSD3 (Declined) (2006-2009)

FUNDING

PI, “Curiosity-driven learning and personalized (re-)education technologies across the lifespan” (2019)

Waterloo-Bordeaux Joint Grant

Awarded: €20,000 Total
With Pierre-Yves Oudeyer (Inria, Bordeaux)

PI, “Teachable Robot for Enhancing Student Curiosity and Learning” (2019)

University of Waterloo Interdisciplinary Trailblazer Grant
Awarded: \$80,000 CAD total
With Elizabeth Nilsen (Psychology, University of Waterloo)

PI, “Promoting Meaningful Learning in Computer Science Courses by Leveraging Concreteness Fading” (2019)

University of Waterloo Learning Innovation and Teaching Enhancement (LITE) Full Grant
Awarded: \$21,226.48 CAD Total

Co-PI, “Public Engagement in Research: Exploring Participatory Research Labor and Employment Roles, Motivations, and Outcomes” (2018)

SSHRC Insight Development Grant
Awarded: \$57,988 CAD Total
With Zack Marshall (School of Social Work, McGill University)

PI, “Doctoral Symposium for HCOMP 2019” (2016)

Artificial Intelligence Journal (AIJ) Grant for Promoting AI Research
Awarded: €9000 Total
With Jenn Wortman Vaughan (Microsoft Research) and Walter Lasecki (School of Information, University of Michigan)

PI, “Curiosity-Driven Learning” (2018)

French Embassy in Canada: Mobility Funding for Researchers
Awarded: €1100 Total

PI, “Designing for Curiosity in Physical Spaces” (2017)

Waterloo-Bordeaux Joint Grant
Awarded: €15,000 Total
With Dana Kulic (ECE University of Waterloo), Pierre-Yves Oudeyer, Martin Hachet, Fabien Lotte (Inria, Bordeaux)

PI, “CrowdCurio: Infrastructure for Research-Oriented Crowdsourcing” (2016)

Canadian Foundation for Innovation (CFI-JELF) and Ontario Research Funds (ORF)
Awarded: \$110,000 CAD Total

PI, “Doctoral Symposium for HCOMP 2016” (2016)

Artificial Intelligence Journal (AIJ) Grant for Promoting AI Research
Awarded: €3000 Total
With Haoqi Zhang (EECS, Northwestern University)

co-PI, “SWaGUR: The Saskatchewan-Waterloo Games User Research Initiative” (2016-2021)

NSERC CREATE Grant
Awarded: \$2,450,000 CAD Total
With PIs Mark Hancock (Management Sciences, University of Waterloo) and Regan Mandryk (CS, University of Saskatchewan)

PI, “A Framework for Hybrid Machine and Human Computation for the Accurate and Scalable Analysis of Human Clinical EEG Recordings” (2015-2019)

NSERC-CIHR Collaborative Health Project (CHRP) Grant
Awarded: \$435,000 CAD Total
With Joelle Pineau (CS, McGill University), Andrew Lim (Neurology, Sunnybrook Hospital)

PI, “Driven by Curiosity: Interaction Techniques and Incentive Mechanisms for Crowdsourcing Scientific Tasks” (2015-2020)

NSERC Discovery Grant
Awarded: \$115,000 CAD Total

co-PI, “Waterloo/Twente Partnership to Accelerate Research in Data Driven Persuasive Health” (2015)

International Research Partnership (IRPG) Grant
Awarded: \$55,000 CAD Total
With PI Catherine Burns (System Design Engineering, University of Waterloo)

“Effectively Leveraging Contributions in Human Computation Systems” (2010-2013)

NSF Social-Computational Systems SoCS Grant
Awarded: \$737,500 USD Total
With PIs Luis von Ahn (CS, Carnegie Mellon University) and Tom Mitchell (Machine Learning, Carnegie Mellon University)

PUBLICATIONS

N.B. Students directly under my supervision marked with *. My name is listed last on papers where I am the lead PI.

Books

- B.1 **E. Law** and L. von Ahn. *Human Computation*. Morgan and Claypool Synthesis Lectures on Artificial Intelligence and Machine Learning, 2011, pages 1-121.

Book Chapters

- B.2 **E. Law**. Human Computation for Music Classification. In Li, T., Ogihara, M., Tzanetakis, G. ed. *Music Data Mining*, CRC Press/Chapman Hall, 2011, pages 281—301.

Refereed Journal Articles (In Computer Science)

- J.1 A. Williams*, G. Mark, K. Milland, E. Lank and **E. Law**. The Perceptual Work Life of Crowdworkers: How Tooling Practices Increase Fragmentation in Crowdsourcing. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-27.
- J.2 M. Schaekermann*, G. Beaton*, M. Habib, A. Lim, K. Larson and **E. Law**. Understanding Expert Disagreement in Medical Data Analysis through Structured Adjudication. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-22.
- J.3 G. d’Eon*, J. Goh, K. Larson and **E. Law**. Paying Crowd Workers for Collaborative Work. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-24.
- J.4 M. Schaekermann*, J. Goh, K. Larson and **E. Law**. Resolvable vs. Irresolvable Disagreement: A Study on Worker Deliberation in Crowdsourcing. In *Proceedings of the ACM on Human-Computer Interaction, vol. 2: Computer-Supported Cooperative Work and Social Computing*, CSCW (2018): 154, pages 1-19. **(Best Paper Award)**

- J.5 W. Challaghan*, J. Goh, M. Mohareb, A. Lim and **E. Law**. MechanicalHeart: A Human-Machine Framework for the Classification of Phonocardiograms. In *Proceedings of the ACM on Human-Computer Interaction, vol. 2: Computer-Supported Cooperative Work and Social Computing, CSCW* (2018): 28, pages 1-17.
- J.6 M. Cartwright, A. Seals, J. Salamon, A. Williams*, S. Mikloska*, D. MacConnell, **E. Law**, J.P. Bello, O. Nov. Seeing Sound: Investigating the Effects of Visualizations and Complexity on Crowdsourced Audio Annotations. In *Proceedings of the ACM on Human-Computer Interaction, vol. 1: Computer-Supported Cooperative Work and Social Computing, CSCW* (2017): 29, pages 1-21.

Refereed Journal Articles (Outside Computer Science)

N.B.: J.4-J.6 are journal publications that resulted from our crowdsourcing systems (CrowdCurio, CrowdEEG) being used by medical and biology scientists to crowdsource annotation of research data.

- J.7 E. Sokolov, D. Abdoul Bachir, F. Sakadi, J.A. Williams, A. Vogel, M. Schaekermann*, N.R. Tassiou, K.A. Bah, V. Khatri, G.C. Hotan, N. Ayub, E.C.W. Leung, T.A. Fantaneanu, A. Patel, M. Vyas, T. Milligan, M. Villamar, D. Hoch, S. Purves, B. Esmaeili, M. Stanley, T. Lehn-Schioler, J. Tellez-Zenteno, E. Gonzalez-Giraldo, I. Tolokh, L. Heidarian, L. Worden, N. Jadeja, S. Fridinger, L. Lee, **E. Law**, C. Fodé Abass, F.J. Mateen. Tablet-based EEG diagnostics for epilepsy patients in the West African Republic of Guinea. In *European Journal of Neurology*, 2020.
- J.8 M. Schaekermann*, N. Hammel, M. Terry, T. Ali, Y. Liu, B. Basham, B. Campana, W. Chen, X. Ji, J. Krause, G. Corrado, L. Peng, D. Webster, **E. Law**, and R. Sayres. Remote Tool-based Adjudication for Grading Diabetic Retinopathy. In *Translational Vision Science & Technology (TVST)*, 8(6): 40, 2019.
- J.9 J. Williams, F.A. Cisse, M. Schaekermann*, F. Sakadi, N.R. Tassiou, G.C. Hotan, A.K. Bah, A. Hamani, A. Lim, E.C.W. Leung, T.A. Fantaneanu, T.A. Milligan, V. Khatri, D.B. Hoch, M.V. Vyas, A.D. Law, J.M. Cohen, A.C. Vogel, **E. Law**, F.J. Mateen. Smartphone EEG and Remote Online Interpretation for Children with Epilepsy in the Republic of Guinea: Quality, Characteristics and Practical Implications. In *Seizure: European Journal of Epilepsy*: 71, 2019, pages 1-7.
- J.10 D. Park, I. Breckheimer, A. Williams*, **E. Law**, A. Ellison and C. Davis. Herbarium specimens reveal substantial and unexpected variation in phenological sensitivity across the eastern United States. In *Philosophical Transactions of the Royal Society B: Biological Sciences*, 374, 2018, pages 1–12.
- J.11 C. Willis, **E. Law**, A. Williams*, B. Franzone, R. Bernardos, L. Bruno, C. Hopkins, C. Schorn, E. Weber, D. Park and C. Davis. CrowdCurio: an online crowdsourcing platform to facilitate climate change studies using herbarium specimens. In *New Phytologist*, 215(1), 2017, pages 479-488.
- J.12 M.A. O’Leary, K. Alphonse, A.H. Mariangeles, D. Cavaliere, A. Cirranello, T. Dietterich, M. Julius, S. Kaufman, **E. Law**, M. Passarotti, J. Robalino, N. Simmons, S. Smith, D. Stevenson, E. Theriot, P. Velazco, R. Walls, M. Yu, M. Daly. Crowd replicate performance of scientific experts scoring phylogenetic matrices of phenotypes. In *Systematic Biology*, 67(1), 2017, pages 49-60.

Refereed Conference Papers

- C.1 *S. Suh, M. Lee, *G. Xia and **E. Law**. Coding Strip: A Pedagogical Tool for Teaching and Learning Programming Concepts through Comics. In *IEEE VL/HCC 2020*.

- C.2 H. Chen*, K. Czarnecki, R. Cohen, K. Dautenhahn, **E. Law**. Autonomous Vehicle Visual Signals for Pedestrians: Experiments and Design Recommendations. In *IEEE Intelligent Vehicles Symposium (IV) 2020*.
- C.3 S. Suh*, M. Lee and **E. Law**. How Do We Design for Concreteness Fading? Survey, General Framework, and Design Dimensions. In *IDC 2020*.
- C.4 M. Alaimi*, **E. Law**, K. Pantasdo*, P-Y. Oudeyer and H. Sauzeon. Pedagogical Agents for Fostering Question-Asking Skills in Children. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-12.
- C.5 M. Schaekermann*, G. Beaton*, E. Sanoubari, A. Lim, K. Larson and **E. Law**. Ambiguity-aware AI Assistants for Medical Data Analysis. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-11.
- C.6 N. Dillen, M. Ilievski, **E. Law**, L. Nacke, K. Czarnecki and O. Schneider. Keep Calm and Ride Along: Passenger Comfort and Anxiety as Physiological Responses to Autonomous Driving Styles. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-12.
- C.7 J. Ceha*, N. Chhibber*, J. Goh, P-Y Oudeyer, C. McDonald, D. Kulic, **E. Law**. Expression of Curiosity in Social Robots: Design, Perception, and Effects on Behaviour. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '19, 2019*, pages 1-12.
- C.8 A. Williams*, J. Goh, C. Willis, A. Ellison, J. Brusuelas, C. Davis and **E. Law**. Deja Vu: Characterizing Worker Reliability Using Task Consistency. In *Proceedings of the AAAI Conference on Human Computation and Crowdsourcing, HCOMP '17, 2017*, pages 197-205.
- C.9 **E. Law**, V. Cai*, E. Liu*, S. Sasy*, J. Goh, A. Blidaru* and D. Kulic. A Wizard-of-Oz Study of Curiosity in Human-Robot Interaction. In *Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN '17, 2017*, pages 1-8.
- C.10 P. Jaini, Z. Chen, P. Carbajal, **E. Law**, L. Middleton, K. Regan, M. Schaekermann*, G. Trimponias, J. Tung, and P. Poupart. Online Bayesian Transfer Learning for Sequential Data Modeling. In *Proceedings of the 5th International Conference on Learning Representations, ICLR '17, 2017*, pages 1-20.
- C.11 **E. Law**, K. Z. Gajos, A. Wiggins, M. Gray and A. Williams*. Crowdsourcing as a Tool for Research: Implications of Uncertainty. In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work and Social Computing, CSCW '17, 2017*, pages 1-18.
- C.12 T. Tse*, J. Salamon, A. Williams*, H. Jiang* and **E. Law**. Ensemble: A Hybrid Human-Machine System for Generating Melody Scores from Audio. In *Proceedings of the International Conference on Music Information Retrieval, ISMIR '16, 2016*, pages 1-7.
- C.13 S. Pan*, K. Larson, J. Bradshaw* and **E. Law**. Dynamic Task Allocation Algorithm for Hiring Workers that Learn. In *Proceedings of the International Joint Conference on Artificial Intelligence, IJCAI '16, 2016*, pages 1-7.
- C.14 **E. Law**, M. Yin, J. Goh, K. Chen*, M. Terry and K.Z. Gajos. Curiosity Killed the Cat, but Makes Crowdwork Better. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '16, 2016*, pages 1-13. **(Best Paper Honorable Mention)**
- C.15 O. Amir, B. Grosz, **E. Law** and R. Stern. Collaborative Health Plan Support. In *Proceedings of the International Conference on Autonomous Agents and Multiagent Systems, AAMAS '13, 2013*, pages 793-796. **(Best Paper Second Prize, Challenges and Visions Track)**

- C.16 H. Zhang, **E. Law**, K.Z. Gajos, E. Horvitz, R.C. Miller and D. Parkes. Human Computation Tasks with Global Constraints: A Case Study. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, CHI '12, 2012, pages 1-10. (**Best Paper Honorable Mention**)
- C.17 **E. Law** and H. Zhang. Towards Large-Scale Collaborative Planning: Answering High-Level Search Queries Using Human Computation. In *Proceedings of the AAAI Conference on Artificial Intelligence*, AAAI '11, 2011, pages 1-6.
- C.18 **E. Law**, B. Settles and T. Mitchell. Learning to Tag using Noisy Labels. In *Proceedings of the European Conference on Machine Learning*, ECML '10, 2010, pages 1-16.
- C.19 **E. Law**, K. West, M. Mandel, M. Bay and S. Downie. Evaluation of Algorithms Using Games: The Case of Music Tagging. In *Proceedings of the International Conference on Music Information Retrieval*, ISMIR '09, 2009, pages 1-6.
- C.20 **E. Law** and L. von Ahn. Input-agreement: A New Mechanism for Data Collection using Human Computation Games. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, CHI '09, 2009, pages 1-10. (**Best Paper Honorable Mention**)

Refereed Short Papers and Extended Abstract

- P.1 **E. Law**, P. Baghaei*, N. Chhibber*, D. Kubic, S. Lin*, K. D. Pantasdo*, J. Ceha*, S. Suh*, N. Dillen*. Curiosity Notebook: A Platform for Learning by Teaching Conversational Agents. In *CHI 2020 Late Breaking Work*.
- P.2 J. Williams, F.A. Cisse, M. Schaeckermann*, F. Sakadi, N.R. Tassiou, A.K. Bah, A.B.D. Hamani, A. Lim, E.C.W. Leung, T.A. Fantaneau, T. Milligan, V. Khatri, D. Hoch, M. Vyas, A. Lam, G. Hotan, J. Cohen, **E. Law** and F. Mateen. (2019). Utilizing a wearable smartphone-based EEG for pediatric epilepsy patients in the resource poor environment of Guinea: A prospective study. In *Annual Meeting of the American Academy of Neurology (AAN) 2019*, pages 1.
- P.3 C. Vandenhof* and **E. Law**. Contradict the Machine: A Hybrid Approach to Identifying Unknown Unknowns. In *Proceedings of the 18th International Conference on Autonomous Agents and Multiagent Systems*, AAMAS '19, 2019, pages 2238-2240.
- P.4 **E. Law**, C. Dalton*, N. Merrill*, A. Young*, K.Z. Gajos. CrowdCurio: A Platform for Supporting Mixed-Expertise Crowdsourcing. In *Proceedings of the AAAI Conference of Human Computation and Crowdsourcing*, HCOMP '13, 2013, pages 1-2.
- P.5 **E. Law**, P. Bennett and E. Horvitz. The Effects of Choice in Routing Relevance Judgments. In *Proceedings of the ACM SIGIR Conference on Research and Development in Information Retrieval*, SIGIR '11, 2011, pages 1-2.
- P.6 **E. Law**, A. Mityagin and M. Chickering. Intentions: A Game for Classifying Search Query Intent. In *Proceedings of the CHI Conference on Human Factors in Computing Systems Work-In-Progress*, CHI '09, 2009, pages 1-4.
- P.7 **E. Law**, L. von Ahn, R. Dannenberg and M. Crawford. TagATune: a Game for Sound and Music Annotation. In *Proceedings of the International Conference on Music Information Retrieval*, ISMIR '07, 2007, pages 1-4.

Refereed Workshop Articles

- W.1 **E. Law**, K.J. Lee* and P. Baghaei*. The Curiosity Notebook: A Platform for Supporting Learning with Teachable Robots. In *HRI 2020 Workshop on Exploring Creative Contents in Social Robots*.

- W.2 **E. Law**, E. Nilsen, K.J. Lee*, A. Chauhan*, J. Ceha*, P. Baghaei*, A. Debbane* and K. Yang*. Learning and Teaching with Conversational Agents. In *CHI 2020 Workshop on Grand Challenges in Conversational UI*.
- W.3 **E. Law** and L. Kuang*. The Role of Experimentation in Human-AI Interaction. In *Proceedings of CHI Workshop on Where is the Human? Bridging the Gap between AI and HCI, 2019*, pages 1-5.
- W.4 **E. Law** and D. Kulic. How to Know When a User is Curious: A Challenge for HRI in Social Robotics. In *Proceedings of CHI Workshop on The Challenges of Working with Social Robots that Collaborate with People, 2019*, pages 1-6.
- W.5 A. Williams*, H. Kaur, **E. Law** and E. Lank. Guiding Attention with Tasks and Emotions in Conversational Agents. In *Proceedings of CHI Workshop on Conversational Agents: Constructing Action Plans from a Wave of Research and Development, 2019*, pages 1-8.
- W.6 N. Chhibber* and **E. Law**. Using Conversational Agents to Support Learning by Teaching. In *Proceedings of CHI Workshop on Conversational Agents: Constructing Action Plans from a Wave of Research and Development, 2019*, pages 1-7.
- W.7 N. Dilen*, **E. Law**, O. Schneider and K. Czarniecki. Passenger-vehicle Interaction in Fully Autonomous Vehicles: current and future trends. In *Proceedings of CHI Workshop on Looking into the Future: Weaving the Threads of Vehicle Automation, 2019*, pages 1-5.
- W.8 G. d'Eon*, K. Larson and **E. Law**. The Effects of Single-Player Coalitions on Reward Divisions in Cooperative Games. In *Proceedings of AAMAS Games, Agents and Incentives Workshop, 2019*, pages 1-15.
- W.9 M. Schaekermann*, G. Beaton*, M. Habib, A. Lim, K. Larson and **Law, E.** (2019). CrowdEEG: A Platform for Structured Consensus Formation in Medical Time Series Analysis. In *Proceedings of the CHI 8th Workshop on Interactive Systems in Healthcare (WISH), 2019*, pages 1-4.
- W.10 M. Schaekermann*, G. Beaton*, M. Habib, A. Lim, K. Larson and **E. Law**. Capturing Expert Arguments from Medical Adjudication Discussions in a Machine-readable Format. In *Proceedings of the WebConf Workshop on Subjectivity, Ambiguity and Disagreement (SAD) on the Web, 2019*, pages 1-7.
- W.11 M. Schaekermann*, **E. Law**, K. Larson, K. and A. Lim. Expert Disagreement in Sequential Labeling: A Case Study on Adjudication in Medical Time Series Analysis. In *Proceedings of the HCOMP Workshop on Subjectivity, Ambiguity and Disagreement (SAD) in Crowdsourcing, 2018*, pages 1-7.
- W.12 N. Chhibber*, R. Syed, M. Teng, J. Goh, K. Collins-Thompson and **E. Law**. Human Perception of Surprise: A User Study. In *Proceedings of SIGIR Computational Surprise Workshop, 2018*, pages 1-4.
- W.13 A. Williams*, A. Vtyurina*, E. Lank and **E. Law**. Designing Voice Interfaces for Accessible Crowdtwork. In *Proceedings of CSCW Workshop on Accessible Voice Interfaces, 2018*, pages 1-4.
- W.14 A. Vtyurina*, A. Fourney and **E. Law**. 5 Seconds After: Exploring User Actions with Voice Assistants in the Moments After a System Response. In *Proceedings of CHI Workshop on Voice-based Conversational UX Studies and Design, 2018*, pages 1-5.
- W.15 A. Williams*, J. Bradshaw*, M. Schaekermann, T. Tse, W. Callaghan and **E. Law**. The Big Picture: Preserving Context in the Decomposition of Complex Expert Tasks. In *Proceedings of the CHI Productivity Decomposed Workshop, 2016*, pages 1-2.

- W.16 M. Schaekermann*, **E. Law**, A. Williams* and W. Callaghan*. Resolvable vs Irresolvable Ambiguity: A new hybrid framework for dealing with uncertain ground truth. In *Proceedings of the CHI Workshop on Human-Centered Machine Learning*, 2016, pages 1-5.
- W.17 **E. Law**, B. Grosz, L.M. Sanders and S.H. Fischer. SimplyPut: Leveraging a Mixed-Expertise Crowd to Improve Health Literacy. In *Proceedings of the AAMAS Workshop on Human-Agent Interaction Design and Models*, 2013, pages 1-10.
- W.18 **E. Law**, B. Settles, A. Snook, H. Surana, L. von Ahn and T. Mitchell. Human Computation for Attribute and Attribute Value Acquisition. In *Proceedings of the CVPR Workshop on Fine-Grained Visual Categorization*, 2011, pages 1-2
- W.19 J. Betteridge, A. Carlson, S. Hong, E.Jr. Hruschka, **E. Law**, T. Mitchell, and S. Wang. Towards Never Ending Language Learning. In *Proceedings of the AAAI Spring Symposium on Learning by Reading and Learning to Read*, 2009, pages 1-2.
- W.20 **E. Law**, L. von Ahn and T. Mitchell. Search Wars: A Game for Improving Web Search. In *Proceedings of the Human Computation Workshop*, 2009, pages 31.
- W.21 **E. Law**. The Problem of Accuracy as An Evaluation Criterion. In *Proceedings of the ICML Workshop on Evaluation Methods for Machine Learning*, 2008, pages 1-4.

INVITED TALKS

Plenary talks

1. *Designing Interactive Systems to Elicit Curiosity*. Invited talk at Conference on Curiosity: Emerging Sciences and Educational Innovations, University of Pennsylvania, Philadelphia, December 2018.
2. *Crowd Computing*. Invited talk at ETH Zurich and Collegium Helveticum. Zurich, Switzerland. December 2017.
3. *The Case of Thoreau's Field Notes: How CrowdCurio Helps to Advance Science and Citizen Science*. Invited talk at HCI International Conference (HCII) 2017 Panel. Vancouver, BC. July 2017.
4. *Designing for Curiosity*. Invited talk at the International Conference on Graphics, Visualization and Human-Computer Interaction (GI). Victoria, BC. May 2016.
5. *Mixed Expertise Crowdsourcing*. Invited keynote at the ICML Workshop on "Machine Learning Meets Crowdsourcing". Atlanta, Georgia. June 2013.
6. *SimplyPut: A Crowdware System for Improving Health Communication and Literacy*. Invited talk at the Academic Pediatric Association Annual Meeting. May 2013.

University colloquia

7. *Socio-technical Challenges in Scientific and Medical Crowdsourcing*. Invited talk at the Carnegie Mellon University HCII and LTI Crowdsourcing Seminar. April 2018.
8. *Designing for Curiosity*. Invited talk at the Toronto User Experience (TUX) Speaker Series. University of Toronto, ON. February 2016.
9. *Balancing Task-Centric and Human-Centric Objectives in Human Computation Systems*. Harvard Center for Research on Computation and Society. Cambridge, MA. September 2012.

Tutorials

10. *Crowdsourcing as a Tool for Research and Public Engagement*. 5-day course at the Digital Humanities Summer Institute, University of Victoria, BC. June 2015.
11. *Human Computation: A Broad Perspective*. 4-hour tutorial at the ACM Intelligent User Interfaces (IUI) Conference. March 2013.
12. *Human Computation: Core Research Questions and State of the Art*. 4-hour tutorial at the AAAI Conference. March 2011.

Industry talks

13. *What should User-Centered Design look like for AI/ML Systems?* Invited talk at Element AI, Toronto, June 2018
14. *The "What" and the "How": Two Studies of Curiosity-Inducing Interfaces.* Microsoft Research Redmond, Redmond, WA. July 2017.

RESEARCH EXPERIENCE

Faculty Fellow, Element AI (Montreal, QC) (2017-present)

Research Intern, Microsoft Research (Redmond, WA) (summer 2010)

Mentors: Paul Bennett and Eric Horvitz

Research Intern, Microsoft Live Labs (Bellevue, WA) (summer 2008)

Mentor: Max Chickering

Research Intern, National Research Council (Ottawa, ON) (summer 1999)

PROFESSIONAL EXPERIENCE

AI Programmer, Ubisoft Entertainment Inc (Montreal, QC) (2005-2006)

Software Developer, IBM Canada (Vancouver, BC) (2000-2003)

Software Developer, Sony Inc. (Tokyo, Japan) (1998)

TEACHING

CS 889: Human-in-the-loop Systems (fall 2014, fall 2015)

This *new* graduate course gives a broad overview of various models for combining human and machine intelligence to solve computational problems. Through weekly seminars and a class project, we examine three roles that humans play in computational systems -- humans as computers, humans as teachers, and humans as collaborators. This course covers both literature from HCI and AI, and the topics include human computation and crowdsourcing, learning by demonstration, mixed initiative systems, active learning from human teachers, and interactive machine learning.

Student Evaluation: 4.2/5 (fall 2014), 4.5/5 (fall 2015)

CS 349: User Interfaces (winter 2015)

This course introduces contemporary user interfaces, including the basics of human-computer interaction, the user interface design/evaluation process, and the architectures within which user interfaces are developed. In 2015, I completely re-structured the course materials for CS349 to teach user interface concepts via web technology (i.e., HTML, CSS, Javascript).

Student Evaluation: 3.7/5 (section 2), 3.8/5 (section 3)

CS 889: Human-AI Interaction (winter 2018)

AI and machine learning technologies has become increasingly integrated with our everyday lives. Yet, such systems are often complex, unpredictable and unfamiliar to users, making it difficult for them to understand, trust and adopt them. This *new* graduate course involves a survey of existing literature on Human-AI interaction, on topics such as safety, fairness, interpretability, ethics, trust, and human-in-the-loop computation. The course is also in part a methodology course---students study different HCI data collection (e.g., experiments, diary studies, interviews, etc.) and analysis (e.g., statistical modeling, grounded theory analysis, etc.) techniques and apply them to research questions related to Human-AI interaction. The coursework involves a weekly seminar and a course project.

Student Evaluation: 4.3/5

CS 449: Human Computer Interaction (spring 2018, fall 2019, spring 2020)

Human-Computer Interaction teaches the fundamental issues that underlie the creation and evaluation of usable and useful computational artifacts. Over the term, students learn how to design novel computational artifacts that enable a well-defined user group to achieve specific goals more effectively. Students learn and directly apply: (1) Rapid ethnography, which includes learning how to perform interviews and in situ observations, (2) User-centered design techniques, including contextual design and low-fidelity, high-iteration prototyping practices (e.g., paper-based prototyping and Wizard-of-Oz studies), (3) Evaluation methods for measuring how a design compares to existing methods of accomplishing a task. The course involves lectures, in-class activities, assigned readings and group projects. In 2018, I restructured the course to be more akin to an interactive *studio*, where students work with instructors and TAs to critique design and refine prototypes in class.

Student Evaluation: 4.2/5 (spring 2018)

Student Evaluation: 4.4/5 (fall 2019)

CS 480: Introduction to Machine Learning (winter 2019)

The course introduces students to the design of algorithms that enable machines to "learn". In contrast to the classic paradigm where machines are programmed by specifying a set of instructions that dictate what exactly a machine should do, a new paradigm is developed whereby machines are presented with examples from which they learn what to do. This is especially useful in complex tasks such as natural language processing, information retrieval, data mining, computer vision and robotics where it is not practical for a programmer to enumerate all possible situations in order to specify suitable instructions for all situations. Instead, a machine is fed with large datasets of examples from which it automatically learns suitable rules to follow. The course will introduce the basics of machine learning and data analysis, and cover human-centered machine learning issues, such as bias, interpretability and AI for social good.

Student Evaluation: 3.9/5 (section 1), 3.7/5 (section 2)

CS 889: Conversational Agents (winter 2020)

Conversational Agents has become increasingly integrated with our everyday lives. This graduate course will explore recent HCI research on conversational agents. The course is also a methodology course---we will study different HCI methodologies (e.g., experiments, diary studies, interviews, etc) and analysis techniques (e.g., statistical modeling, grounded theory analysis) and apply them to research questions related to conversational agents. There are three main components: Paper Critique, Presentation, Project. The coursework involves a weekly seminar and a course project.

STUDENTS AND POSTDOCS SUPERVISION

Postdoc Supervision

Apoorva Chauhan (2019 – present)

Graduate/Thesis Supervision

Sangho Suh (Ph.D.) (2017 – present)

Jessy Ceha (Ph.D.) (2017 – present)

Alexandra Vtyurina (Ph.D., co-advised with Charlie Clarke) (2017 – present)

Amy Gabriela Debbane (M.Math.) (2020 - present)

Graduate/Thesis Supervision (Graduated)

Mike Schaekermann (Ph.D., co-advised with Kate Larson) (Applied Scientist, Amazon)

Colin Vandenhof (M.Math) (Graduated)

Nalin Chhibber (M.Math.) (Research Engineer at AutoDesk)

Alex Williams (Ph.D., co-advised with Ed Lank) (Assistant Professor at U. Tennessee Knoxville)

Greg D'Eon (M.Math., co-advised with Kate Larson) (Ph.D. student at UBC)

William Callaghan (M.Math.) (Data Engineer, Borealis.AI Montreal)

Sundra Yunjia Sun (M.Math, co-advised with Ed Lank) (Google Waterloo)

Tim Tse (M.Math., co-advised with Pascal Poupart)

Undergraduate Supervision

| | |
|-----------------------------------|--------|
| Ken Jen Lee (URA/URF) | (2019) |
| Jarvis Xie (URA) | (2019) |
| Amy Gabriela Debbane (URA) | (2019) |
| Gracie Xia (URA) | (2018) |
| Kevin Pantasdo (URA) | (2018) |
| Steven Feng (URA) | (2018) |
| Helga Jiang (URA, co-op) | (2017) |
| Meng Dong (URA, undergrad thesis) | (2017) |
| Stephanie Mikloska (URA) | (2016) |
| Clarice Ng (URA) | (2016) |
| Eddie Du (URA) | (2016) |
| Maoning Guo (URA) | (2016) |
| Jing Tao (URA) | (2016) |
| Mark Martinez (URA) | (2016) |
| Josh Bradshaw (research co-op) | (2015) |
| Tiasa Mondol (URA) | (2015) |
| Kevin Chen (URA) | (2015) |
| Charlie Wu (URA) | (2015) |
| Ruiming Zhu (URA) | (2014) |
| Rui Lin (URA) | (2014) |
| Wenchao Du (URA) | (2014) |
| Susu Dong (URA) | (2014) |
| Elkan Wang (URA) | (2014) |

Former Students

| | |
|--|---------------------------------|
| Louis Kuang (M.Math., co-advised with Kate Larson) | (Google Waterloo) |
| Kexin Yang (M.Math.) | (Ph.D student, Carnegie Mellon) |

THESIS EXAMINATION COMMITTEE

| | |
|--|---------|
| Neil Budnarain (Masters Thesis) | (2020) |
| Alex Yun (Masters Thesis) | (2020) |
| Lingheng Meng (Ph.D. Thesis) | (2020) |
| Carter Cousineau (Ph.D. Thesis), University of Guelph | present |
| Hemant Surale (Ph.D. Thesis) | (2020) |
| Bahreh Sarrafzadeh (Ph.D. Thesis) | (2020) |
| Henry Chen (Masters Thesis) | (2020) |
| Johann David Wentzel (Masters Thesis) | (2020) |
| Nicole Dillen (Masters Thesis) | (2019) |
| Alexander Butyaev (External Examiner, McGill University, Ph.D. Thesis) | (2019) |
| Gustavo Fortes Tondello (Ph.D. Thesis) | (2019) |
| Murat Dikmen (Ph.D. Comprehensive) | (2019) |
| Alex Bildaru (Masters Thesis) | (2019) |
| Jeff Avery (Ph.D. Thesis) | (2018) |
| Caroline Lamb (Ph.D. Thesis) | (2018) |
| Yetian Wang (Ph.D. Comprehensive) | (2018) |
| Gustavo Fortes Tondello (Ph.D. Comprehensive) | (2018) |
| Diane Watson (Ph.D. Comprehensive) | (2017) |
| Yunjia Sun (Masters Thesis) | (2016) |
| Quifan Li (Masters Thesis) | (2016) |
| Matthew Chan (Masters Thesis) | (2016) |
| Shengyin Pan (Masters Thesis) | (2015) |
| Brent Komer (Masters Thesis) | (2015) |
| Carolyn Lamb (Ph.D. Comprehensive) | (2015) |

Mingyu Liu (Masters Thesis) (2015)
Marta Kryven (Ph.D. Comprehensive) (2015)

MAJOR PROFESSIONAL SERVICE

Conference Leadership:

HCOMP: AAAI Conference on Human Computation and Crowdsourcing (2019)
General and Program co-Chair

OTHER PROFESSIONAL SERVICE

Conference Organizing Committees:

CSCW: ACM Conference on Computer-Supported Cooperative Work and Social Computing (2019)
Panels co-Chair

CHI: ACM Conference on Human Factors in Computing Systems (2019)
Accessibility co-Chair

WebConf: The Web Conference (formerly WWW) (2019)
Track co-Chair, Crowdsourcing and Human Computation Track

HCOMP: AAAI Conference on Human Computation and Crowdsourcing (2016)
Doctoral Symposium co-Chair

Workshop Organizing Committees:

CHI: Designing for Curiosity: An Interdisciplinary Workshop (2017)

CSCW: Science of Citizen Science: Theories, Methodologies and Platforms (2017)

HCOMP: Citizen + X: Crowdsourcing in Science, Public Health and Government (2014)

NIPS: Human Computation for Science and Computational Sustainability (2012)

AAAI: Human Computation Workshop (HCOMP) (2011-2012)

KDD: Human Computation Workshop (HCOMP) (2009-2010)

Conference Program Committees as Associate Chair or Senior Program Committee Member:

AAAI: Conference on Artificial Intelligence (2019)

CHI: ACM Conference on Human Factors in Computing Systems (2019, 2020)

IDC: ACM Interaction Design and Children Conference (2019)

CSCW: ACM Conference on Computer-Supported Cooperative Work and Social Computing (2015, 2018)

CHI Play: ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play (2015)

Conference Program Committees as PC member:

C&C: ACM Creativity and Cognition Conference (2019)

CI: Collective Intelligence (2018)

GI: Graphics Interface Conference (2018)

UMAP: ACM Conference on User Modeling, Adaptation and Personalization (2018)

SIGIR: ACM Conference on Research and Development in Information Retrieval (2018)

WWW: International World Wide Web Conference (2014, 2017, 2018)

IJCAI: International Joint Conference on Artificial Intelligence (2016)

HCOMP: AAAI Conference on Human Computation and Crowdsourcing (2013, 2014)

AAAI: Conference on Artificial Intelligence (2012, 2013)

ICWSM: International AAAI Conference on Web and Social Media (2010)

Reviewer of Conference Publications:

CogSci: Annual Meeting of the Cognitive Science Society (2019)

HRI: ACM/IEEE International Conference on Human-Robot Interaction (2019)

IDC: ACM Interaction Design and Children Conference (2018)

CHI: ACM Conference on Human Factors in Computing Systems (2009-present)

UIST: ACM Symposium on User Interface Software and Technology (2011, 2013-2016, 2018)

IUI: ACM International Conference on Intelligent User Interfaces (2011)

NIPS: Conference on Neural Information Processing Systems (2011, 2012)

ICRA: IEEE International Conference on Robotics and Automation (2012)
CSCW: ACM Conference on Computer Supported Cooperative Work (2016, 2018)

Workshop Program Committees:

IEEE PerCom: Annotation of User Data for Ubiquitous Systems (2017)
KDD: Interactive Data Exploration and Analytics Workshop (2016)
EC: Crowdsourcing and Online Behavioral Experiments (2014)
ECIR: Gamification for Information Retrieval (2014)
KDD: Crowdsourcing and Data Mining (2012)
AAAI: Wisdom of the Crowd (2012)
NIPS: Computational Social Science and the Wisdom of the Crowds (2010-2011)
SIGIR: Crowdsourcing for Information Retrieval (2011)

Reviewer of Journal Publications:

Journal of Experimental Psychology (2020)
Transactions on Learning Technologies (2018)
ACM Transactions on Interactive Intelligent Systems (TiiS) (2017)
ACM Transactions on Computer-Human Interaction (ToCHI) (2014)
Transaction on Pattern Analysis and Machine Intelligence (2014)
ACM Transactions on Intelligent Systems and Technology (TIST) (2012)
Journal of Information Retrieval: Special Issue on Crowdsourcing (2011)
EURASIP Journal on Audio, Speech and Music Processing (2011)
Citizen Science: Theories and Practice (2016)

Reviewer of Book Proposals:

Cambridge University Press (2017)

Grant Review Panels

NSF (2015, 2016)
NSERC-CIHR Collaborative Health Research (CHRP) Project (2015, 2019)

Journal Editorial Boards:

PACMHCI: Proceedings of ACM-HCI (as Information Director) (2017—present)
Citizen Science: Citizen Science: Theory and Practice (as Board Member) (2015 – 2017)

Advisory Boards:

Linguistic Data Consortium: NSF Computing Research Infrastructure project titled “Novel Incentives and Workflows in Linguistic Data Collection and Annotation” (2017 – present)
Cornell: NSF project titled “Crowd ID: Collaborative Tools Connecting People to Biodiversity through Social Networks and Machine Learning” (2010 – 2014)
Penn State University: NSF IGERT project titled “Big Data Social Science” (2013 – 2014)

DEPARTMENTAL SERVICE

Graduate/Admission Committee: (2019-present)

University of Waterloo Interdisciplinary Task Force (2019-2020)

Member, Graduate Recruiting Committee: (2014-2019)

Chair, Graduate Recruiting Committee: (2020-present)

I proposed and helped create a new graduate recruiting event called Undergraduate Research Opportunities Conference (UROC), where we invite top undergraduate students from across Canada to come to University of Waterloo for a 3-day program, to learn about graduate school and our research in computer science. As a direct result of this new conference, many UROC attendees ended up applying to graduate

school at University of Waterloo as well as other universities in Canada and abroad. The conference was an annual event from 2015-2018.