Advances in Programming Languages and Neurosymbolic Systems (AIPLANS)

Breandan Considine[1,5], **Disha Shrivastava**[1,3,5],
David Yu-Tung Hui[2,5], **Chin-Wei Huang**[2,5], **Shawn Tan**[2,5]
Prakash Panangaden[1,5], Xujie Si[1,5], Stefan Monnier[2], Danny Tarlow[1,3,5], Guy Van den Broeck[6]
McGill University[1], Université de Montréal[2], Google Research[3], HEC[4], Mila[5], UCLA[6]
`{considib, shrivast, huidavid, huangchi, tanjings}@mila.quebec`

Tagline: AIPLANS: a new workshop at NeurIPS 2021 fusing ML with programming theory to create neurosymbolic program-writing machines! `https://aiplans.github.io`

Neural information processing systems have benefited tremendously from frameworks for automatic differentiation (AD). These frameworks are **programming languages** which consist of differentiable and stochastic primitives. When combined with neural language models, such systems are increasingly capable of generating symbolic programs a human programmer might write in a high-level language. Developing **neurosymbolic systems** for automatic program synthesis will require insights from both statistical learning and programming language research. AIPLANS is designed to be as inclusive as possible towards all researchers building PLs and neurosymbolic systems of various forms, e.g.:

- **Machine learning researchers** would present advances in meta-learning, reinforcement learning and program synthesis. AIPLANS would afford these participants an opportunity to learn about new automatic programming languages and techniques for inference.

- **Language designers** would be able to give tutorials on newly developed software such as JAX, DEX, PyTorch and their latest features. AIPLANS would give them an opportunity to engage their users and stay in touch with the community's needs and research directions.

- **PL theorists** would present fundamental theory behind the design of automatic programming languages, such as functional, semiring or array programming. At AIPLANS, they would gain a better understanding of practical research problems the ML community is tackling.

- **Probabilistic programming researchers** would present progress in a long history of extending programming paradigms (e.g. functional or logic programming) to handle learning and uncertain reasoning. AIPLANS would provide them with new insights for extending these (often symbolic) languages with primitives for expressing neural models.

Prior workshops [10, 12, 11] have explored each of these themes separately, but few have highlighted the synergies between them and historically, many ideas have been rediscovered independently. AD itself was invented at least half a dozen times over the last century [4] and research continues to reveal unexpected connections to implicit differentiation [8], bilevel optimization [18], optimal control [17], differential equations [7] and stochastic processes [15]. Semiring programming [14] has existed for decades and shares deep connections to reinforcement learning [2] and probabilistic programming [5].

Likewise, many recently-transplanted ideas in machine learning are catechism in the programming language literature [9]. For example, functional and type-safe programming are lingua franca in PL circles but relatively new to Python, the primary language used in machine learning. The duality between code and data is well-known in PL under the aegis of homoiconicity [1]. PL theory has thought carefully about categorical semantics [3], process calculi [6], linear logic [13], type theory [16] and other deeply useful concepts which remain, to this day, largely unfamiliar to the machine learning community. A joint workshop such as the one put forth in this proposal could help to facilitate yet-unrealized research connections among neighboring fields.

Workshop Logistics

AIPLANS will be a one-day workshop hosted online, enabling an economically and geographically diverse audience to participate. Talks will be hosted in English, following the standard format of oral presentations and panel discussions, to be concluded with a virtual poster session. Proceedings will be non-archival. Outside of standard videoconferencing and SlidesLive assistance, we anticipate no other technical requirements. If accepted, we expect to receive a hundred or so participants, including speakers and workshop submitters, based on attendance at similarly-themed workshops in prior years. A list of confirmed speakers (pending workshop acceptance) may be found below:

Marie Kerjean (LIPN)	Joshua Tenenbaum (MIT)	Gail Weiss (Technion)
Ryan Adams (Princeton)	Alexander Rush (Cornell)	David Duvenaud (Toronto)

The workshop itself will run for approximately eight hours during daylight savings time on five continents, and feature up to four 45-minute keynote talks and up to six 20-minute contributed talks. In addition, AIPLANS will solicit four-page paper submissions in a CFP to be circulated pending workshop acceptance. To encourage submissions from the broader ML/PL community, accepted authors will be given an opportunity to showcase their work in a virtual poster session or lightning talk for outstanding contributions. We expect to receive 20-30 submissions in total, and pledge that each paper will receive at least two fair and independent reviews. To minimize potential conflicts of interest, AIPLANS will manage submissions via the OpenReview conference management toolkit.

Those who traditionally publish in venues such as SIGPLAN and SIGSOFT are encouraged to submit work that may be considered relevant to the machine learning and reasoning community, provided that effort is taken to ensure its accessibility. Special consideration will be given to didactic submissions of outstanding clarity. Further information, including evaluation criteria, examples of relevant literature, deadlines and workshop logistics will be made available in a timely manner.
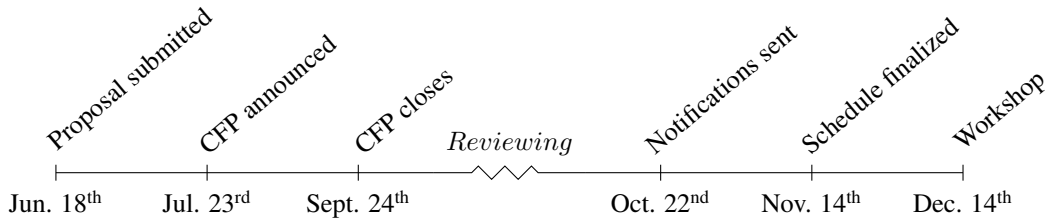

Figure 1: A tentative timeline for our proposed workshop at NeurIPS 2021.

If accepted, AIPLANS will announce its CFP and pursue contributions from the broader ML/PL community shortly thereafter. Two months later, the CFP will close on Sept. 17th. This deadline may be extended to no later than Sept. 24th, depending on the volume of submissions received, leaving sufficient time for referees and program chairs to leave feedback. Authors will be notified of acceptance no later than Oct. 22nd. We intend to finalize the schedule and coordinate presentation logistics between Nov. and Dec. 14th. Those who wish to prerecord talks will be given an opportunity to do so. The final workshop will consist of prerecorded and live talks with Q&A, followed by a moderated panel, and virtual poster session hosted on GatherTown. Further details about schedule and logistics will be made available, pending acceptance at: `https://aiplans.github.io/`.

AIPLANS is an equal-opportunity workshop that celebrates cultural, linguistic, ethnic and intellectual diversity in all forms. Not only are we committed to nondiscrimination on the basis of, e.g., race, creed, age, gender, orientation, physical or mental handicap, but also aim to encourage individuals from other disadvantaged and underrepresented socioeconomic backgrounds to participate. Should our workshop be accepted, scholarships covering the cost of registration will be extended for those who wish to attend but would otherwise be unable to do so due to financial hardship. Financial support for this initiative may be supplemented by industry sponsorship if necessary.

# Confirmed Workshop Organizers
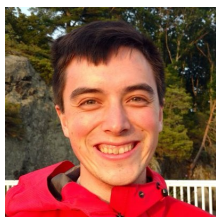
Breandan Considine is a Ph.D. student at McGill University co-supervised by Jin Guo and Xujie Si. His research studies how to reason about the behavior of real-world programs and use those insights to build more intelligent programming tools for developers. This year, he organized the Computer Calculus RG and co-organized the ICLR workshop, Rethinking ML Papers. Breandan is enthusiastic about AI as a tool for augmenting human reasoning and eager to help bring together PL and ML researchers at AIPLANS.

🏠 https://breandan.github.io 🐦 @breandan

Disha Shrivastava is a Ph.D. student at Mila, working with Hugo Larochelle and Danny Tarlow. She also works part-time at Google Brain, Montreal as a Student Researcher. Earlier, she worked at IBM Research, India as a Research Software Engineer for two years on unsupervised construction of knowledge graphs, metrics for computational creativity and topical coherence. Disha's current research studies code representation learning, program synthesis, meta-learning, out-of-distribution generalization, structured prediction with discrete latent variables and reasoning-based systems for QA tasks. She has co-organized the ML for Creativity workshop at KDD 2017.

🏠 https://shrivastavadisha.github.io 🐦 @DishaShrivasta9
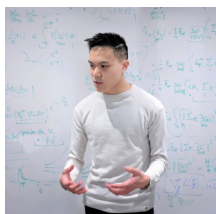
David Yu-Tung Hui is a M.Sc. student at Mila, Université de Montréal, co-advised by Pierre-Luc Bacon and Aaron Courville. David researches the design of software enabling (robotic) agents to follow procedural instructions in natural language or code. He helped develop the BabyAI environment to investigate instruction following and helps maintain the GitHub repository.

🏠 https://dyth.github.io 🐦 @dythui

Chin-Wei Huang is a Ph.D. candidate at Mila, Université de Montréal. He primarily works on likelihood-based generative models and efficient algorithms for approximate inference. He is the lead organizer of the Workshop on Invertible Neural Networks, Normalizing Flows, and Explicit Likelihood Models at ICML (2019-2021) and has contributed to the development of efficient likelihood and unbiased gradient estimation of Convex Potential Flows and Score-Based Diffusion Models using automatic differentiation.
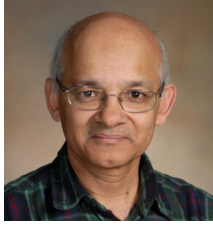
🏠 https://chinweihuang.com 🐦 @chinwei_h
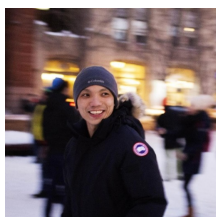
Shawn Tan is a Ph.D. candidate at Mila, Université de Montréal. He is interested in differentiable methods for structured prediction, specifically in the domain of natural language. He co-authored the Ordered Neurons paper which won best paper at ICLR 2019.

🏠 http://blog.wtf.sg 🐦 @tanshawn

Confirmed Program Committee

Prakash Panangaden is a Professor at McGill University. He has three research areas: (a) semantics and logics for probabilistic systems and languages (b) machine learning and (c) quantum information theory. His research studies the approximation of continuous-state systems and associated metrics and logics. He is working on a quantitative extension of equational logic for approximate equational reasoning. Prakash is also interested in duality for automata and using it for minimization. He has recently begun working on diffusion and similar continuous-time Markov processes.

⌂ https://www.cs.mcgill.ca/~prakash 🐦 @prakash127

Xujie Si is an Assistant Professor and Canada CIFAR AI Chair in the School of Computer Science at McGill University and at Mila - Quebec AI Institute. He finished his Ph.D. in Computer and Information Science at the University of Pennsylvania in 2020, advised by Prof. Mayur Naik. Xujie received his M.S. in computer science from Vanderbilt University in 2014, before which he obtained his B.E. (with Honors) from Nankai Unversity in 2011. He spent the summer of 2019 as a research scientist intern at DeepMind working with Pushmeet Kohli in the Robust AI team.

⌂ https://www.cs.mcgill.ca/~xsi 🐦 @XujieSi

Stefan Monnier is interested in the design and implementation of strongly typed programming languages. He sees a future where all programming is done in type safe languages or in assembly supplemented with safety proofs. He is also interested in investigating what such a future means in terms of how we distribute the work between compilers, runtime systems, operating systems and computer architecture. For this reason Stefan's main focus has been at the intersection between type-safety and memory-management.

⌂ https://www.iro.umontreal.ca/~monnier

Danny Tarlow is a Research Scientist at the Google Brain team in Montreal. He is primarily interested in machine learning methods for understanding and generating programs, but has broad interests across Machine Learning. Danny is also an Adjunct Professor in the School of Computer Science at McGill University and an associate member at Mila, where he co-supervises a couple PhD students. He holds a PhD from the Machine Learning group at University of Toronto (2013) and before coming to Montreal, spent four years as a postdoc and then researcher at Microsoft Research, Cambridge.

⌂ https://research.google/people/DannyTarlow 🐦 @dtarlow2

Guy Van den Broeck is an Associate Professor and Samueli Fellow at UCLA, in the Computer Science Department, where he directs the Statistical and Relational Artificial Intelligence (StarAI) lab. His research interests are in Machine Learning (Statistical Relational Learning, Tractable Learning), Knowledge Representation and Reasoning (Graphical Models, Lifted Probabilistic Inference, Knowledge Compilation), Applications of Probabilistic Reasoning and Learning (Probabilistic Programming, Probabilistic Databases), and Artificial Intelligence in general.

⌂ https://web.cs.ucla.edu/~guyvdb 🐦 @guyvdb

References

[1] Harold Abelson and Gerald Jay Sussman. *Structure and interpretation of computer programs*. The MIT Press, 1996.

[2] John S Baras and George Theodorakopoulos. Path problems in networks. *Synthesis Lectures on Communication Networks*, 3(1):1–77, 2010.

[3] Michael Barr and Charles Wells. *Category theory for computing science*, volume 49. Prentice Hall New York, 1990.

[4] Atilim Gunes Baydin, Barak A Pearlmutter, Alexey Andreyevich Radul, and Jeffrey Mark Siskind. Automatic differentiation in machine learning: a survey. *Journal of machine learning research*, 18, 2018.

[5] Vaishak Belle and Luc De Raedt. Semiring programming: A semantic framework for generalized sum product problems. *International Journal of Approximate Reasoning*, 126:181–201, 2020.

[6] Richard Blute, Josee Desharnais, Abbas Edalat, and Prakash Panangaden. Bisimulation for labelled markov processes. In *Proceedings of the 12th Annual IEEE Symposium on Logic in Computer Science*, LICS '97, page 149, USA, 1997. IEEE Computer Society.

[7] Ricky TQ Chen, Yulia Rubanova, Jesse Bettencourt, and David Duvenaud. Neural ordinary differential equations. *arXiv preprint arXiv:1806.07366*, 2018.

[8] Bruce Christianson. Reverse aumulation and imploicit functions. *Optimization Methods and Software*, 9(4):307–322, 1998.

[9] Alonzo Church. *The Calculi of Lambda-conversion*. Annals of Mathematics Studies. Princeton University Press, 1941.

[10] Baydin et al. Languages for Inference Workshop. 2019.

[11] Sutton et al. Workshop on Computer-Assisted Programming. 2020.

[12] Wiltschko et al. Program Transformations for machine Learning Workshop. 2019.

[13] Jean-Yves Girard. Linear logic. *Theoretical computer science*, 50(1):1–101, 1987.

[14] Michel Gondran and Michel Minoux. *Graphs, dioids and semirings: new models and algorithms*, volume 41. Springer Science & Business Media, 2008.

[15] Xuechen Li, Ting-Kam Leonard Wong, Ricky TQ Chen, and David Duvenaud. Scalable gradients for stochastic differential equations. In *International Conference on Artificial Intelligence and Statistics*, pages 3870–3882. PMLR, 2020.

[16] Per Martin-Löf and Giovanni Sambin. *Intuitionistic type theory*, volume 9. Bibliopolis Naples, 1984.

[17] Evgenii Nikishin, Romina Abachi, Rishabh Agarwal, and Pierre-Luc Bacon. Control-oriented model-based reinforcement learning with implicit differentiation. *arXiv preprint arXiv:2106.03273*, 2021.

[18] Bradly Stadie, Lunjun Zhang, and Jimmy Ba. Learning intrinsic rewards as a bi-level optimization problem. In *Conference on Uncertainty in Artificial Intelligence*, pages 111–120. PMLR, 2020.