Advances in Programming Languages and Neurosymbolism (AIPLANS II)

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Tagline: AIPLANS: Fusing machine learning with programming language theory to create neurosymbolic programming machines! `https://aiplans.github.io`

Since the first AIPLANS workshop at NeurIPS 2021, rapid progress has been made on uniting the two divergent branches of computer science: machine learning (ML) and programming languages (PL). What was once a fringe research area has begun to catalyze a broader movement, with summer schools [8, 4], workshops [2, 1, 7, 6] and tutorials [9, 3, 10] dedicated to neurosymbolic research in recent years. From the connectionists, descended the present generation of large langauge models, inspired by biological systems and immersed in probability, statistics and linear algebra. And from the symbolists came programming languages, compilers, and automated theorem provers, powering the digital revolution which made this endevor even possible.

AIPLANS seeks to harness the emergent capabilities of large language models to the explainability and rigor of the symbolic method, taking inspiration from the experimentalist, language designer, programming enthusiast, and formalist alike. But how do we build systems with the prowess of large language models while retaining the safety and trustworthiness of programming langauges? Can we make them flexible enough to behave naturally while simple enough to be interpretable? And how do we guaratnee these systems plan and act safely amidst humans? At AIPLANS, we aim to explore these questions with an eye towards *program synthesis* – human-readable and mechanically verifiable specifications that can be interpreted by a computer. In a series of invited talks, contributed papers, and panel discussions, we plan to cover some of the following areas:

- Probabilistic model checking
- Language induction
- Proof search and program synthesis
- Declarative programming
- Constraint satisfaction
- Unification, completion and resolution
- Analytic combinatorics
- Computational group theory
- Vector symbolic architectures
- Automata and formal grammars
- Formal aspects of language modeling [5]
- Constrained sampling from LLMs
- Randomized complexity
- Algorithmic information theory
- Circuit lower bounds
- Reachability problems
- Proof assistance and automation
- Type theory and semantics

While prior workshops have focused on generating source code, AIPLANS is more concerned with the theory and practice of formal language modeling, as well as the synthesis of interpretable and verifiable programs. Rather than treating computer programs as ordinary strings, an emerging body of neurosymbolic literature explores the computational expressivity of LLMs, logics for tractable inference, learnability of formal languages, as well as methods for sampling programs in a controlled

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and efficient manner and evaluating the systematic and compositional generalization of LLMs to tasks of increasing computational complexity.

Probabilistic programming

Probabilistic programming languages (PPLs) are domain-specific languages (DSLs) expressing probabilistic models and inference algorithms, performing stochastic computation and reasoning about uncertainty. They typically implement common operations such as generating pseudorandom numbers, estimating probability density functions and manipulating them by condititiong, marginalization, sampling and efficiently calculating expectations and higher moments. More sophisticated PPLs enable users to prove higher-order properties of probabilistic programs such as rates of convergence, concentration bounds and amortized analysis of algorithms.

Program synthesis

Program synthesis is broadly interested in generating programs that satisfy a specification, whether from a natural language description, input-output examples, or logical formulae. This area of research is closely related to langauge induction, and it shares close ties with formal methods, probabilistic programming and symbolic regression. The goal of program synthesis is not to generate source code per se, but to automate the process of programming, and to generate programs that are correct by construction.

Formal language theory

The theory of computation is the true *sanctum sanctorum* for programming language and machine learning research. Formal language theory tells us exactly what is and is not possible, how hard it will be, and if one poses the right questions, a constructive mechanism for how to realize it in silico. Unlike machine learning, FLT does not deal with empirical observations, but a priori truth. The tools it provides rigorously characterize the properties of languages and computing machinery, such as their expressivity, learnability and generalization. This area of research is essential for understanding the limits of what can be learned and computed and is a cornerstone of AIPLANS.

Neuralsymbolic systems

At the end of the day, AIPLANS is about building neurosymbolic systems that work in practice. Special attention will be given to submissions that are not toy academic prototypes, but real-world systems that have been deployed in production, or have an active user base. We are particularly interested in case studies on integrating neurosymbolic systems into existing software stacks, and how they have been used to solve real-world problems. Some examples come to mind: Wolfram Alpha, Gurobi, Microsoft Excel, Outlines [11], etc., although preferably submissions will have some academic or research component and are not PR pieces for a commercial product.

Proposed Workshop Logistics

AIPLANS will be a one-day in-person workshop with live talks and panels. Talks will be hosted in English, following the standard format of oral presentations and panel discussions, to be concluded with a poster session. Proceedings will be non-archival. Outside of standard videoconferencing and SlidesLive assistance, no other technical requirements are necessary. We anticipate receiving roughly 200 participants, including speakers and workshop submitters, based on our experience running AIPLANS at NeurIPS 2021 and attendance at similarly-themed workshops in prior years.

The workshop itself will run for approximately eight hours, featuring four 45-minute contributed talks and up to six 20-minute contributed talks, with a strong preference for in-person attendance. 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 poster session, and exceptional contributions may be selected for a short spotlight talk. We expect to receive 30-40 submissions, 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 OpenReview.

Those who traditionally publish in venues such as SIGPLAN, SIGSOFT and other ACM venues are encouraged to submit work they consider relevant to a machine learning audience, provided that effort is taken to ensure its accessibility. Special consideration will be given to pedagogical submissions of outstanding clarity. Further information, including evaluation criteria, examples of relevant literature, deadlines and workshop logistics will be provided for reference.

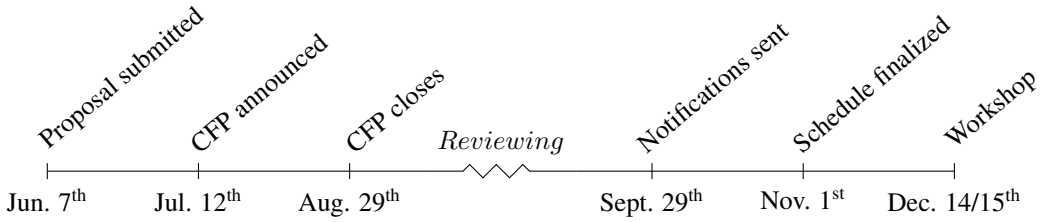
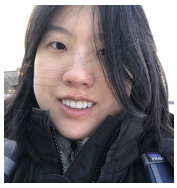


Figure 1: A tentative timeline for our proposed workshop at NeurIPS 2024.

If accepted, AIPLANS will announce its CFP and pursue contributions from the broader ML/PL community shortly thereafter. Six weeks later, the CFP will close on Aug. 29$^{\text{th}}$. This deadline may be extended to no later than Sept. 5$^{\text{th}}$, depending on the volume of submissions received, leaving sufficient time for referees and program chairs to give feedback. Authors will be notified of acceptance no later than Sept. 29$^{\text{th}}$. We intend to finalize the schedule and coordinate presentation logistics between Nov. 1$^{\text{st}}$ and Dec. 14$^{\text{th}}$. 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 poster session. 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. If needed, AIPLANS may pursue industry sponsorship for this initiative to enable a wider audience to attend. Further details about registration and funding availability will be provided in a timely manner.

Confirmed Workshop Organizers



Jialu Bao is a Ph.D. student at Cornell advised by Prof. Justin Hsu, who is working on the verification of randomized algorithms. Before moving to Cornell with her advisor, she spent two years at University of Wisconsin – Madison as a Ph.D. student, and prior to that, did her undergrad at Cornell majoring in Mathematics and Computer Science.

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Maddy Bowers is a Ph.D. student at MIT, co-advised by Armando Solar-Lezama in EECS and Josh Tenenbaum in BCS, whose research combines methods from programming languages (PL) research with machine learning to tackle problems in artificial intelligence.

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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 build more intelligent programming tools for developers. Previously, he organized the first AIPLANS workshop at NeurIPS and co-organized the ICLR workshop, Rethinking ML Papers.

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Younesse Kaddar is a Ph.D. student in theoretical computer science at the University of Oxford, working on programming language semantics, Bayesian probabilistic programming, and category theory. Previously, he was a visiting researcher at Mila, Québec working with Yoshua Bengio.

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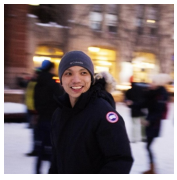
Justine Gehring is a research engineer at Moderne working in the field of Machine Learning (ML) for code and Graph Neural Networks (GNNs). Her focus lies in generating code under challenging circumstances, specifically in scenarios such as sparse data where library-specific code is required, as well as managing a substantial amount of code at a time. She completed her Master's Degree in Computer Science at Mila & McGill.

`https://justine-gehring.github.io/` @GehringJustine



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.

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Confirmed Program Committee

David Chiang is a Professor at Notre Dame University. His research is in natural language processing, the subfield of computer science that aims to enable computers to understand and produce human language. He focuses mainly on language translation, and has interests in syntactic parsing and other areas as well.

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Parisa Kordjamshidi is an assistant professor at Michigan State University and director of the Heterogeneous Learning and Reasoning (HLR) lab. Her main research interests are artificial intelligence, machine learning, natural language processing, and declarative learning based programming (DeLBP). She works on the extraction of formal semantics and structured representations from natural language, with a specific focus on spatial semantics representation and structured output learning models.

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Nikolay Malkin is an Associate Professor at the University of Edinburgh working on algorithms for deep-learning-based reasoning and their applications, in particular induction of compositional structure in generative models, modeling of posteriors over high-dimensional explanatory variables, uncertainty-aware explanations for observed data, human-like symbolic, formal, and mathematical reasoning and tracking land use patterns over time and monitoring the effects of climate change.

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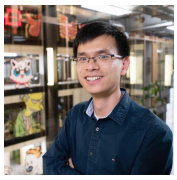

Xujie Si is an Assistant Professor and Canada CIFAR AI Chair in the School of Computer Science at the University of Toronto and Vector Institute. He finished his Ph.D. in Computer and Information Science at the University of Pennsylvania in 2020, advised by Prof. Mayur Naik. Xujie received his M.S. in computer science from Vanderbilt University in 2014, before which he obtained his B.E. (with Honors) from Nankai Unversity in 2011.

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