
— Bachelor's / Master's Thesis —

Closed-Form Operations on Probability Generating Functions

What is it all about?

Machine Learning is *the* topic nowadays, but how do we teach machines besides deep learning mechanisms and neural networks? Mostly, Bayesian sometimes also called probabilistic machine learning is used. In case of neural networks, the teaching itself heavily relies on gradient-based methods for regression and classification. On the other hand, for probabilistic machine learning, [inference](#) is a crucial ingredient. Automated differentiation tools are to the former, as [probabilistic programming](#) is to the latter.

Probabilistic programming is fundamentally about [developing languages and semantics](#) that enables the denotation of inference programs and [simple evaluation methods](#) that “solve” those inference problems. More about probabilistic programming can be found here [vdMPYW18, Kam19].

In our approach, we use the [probabilistic variant of Guarded Command Language](#) (pGCL) developed by Dijkstra, McIver and Morgan et. al. to model probabilistic programs. The semantics, however, is defined on the concept of [formal power series](#) and [generating functions](#) [Wil06]. The main benefit of using these encodings is the usage of so called [closed-forms](#). For example the infinite series $\sum_{i=0}^{\infty} X^i$ can be uniquely represented as $\frac{1}{1-X}$.

What is to be done?

1. Capturing a precise definition of a closed-form
2. Which operations defined in pGCL can be evaluated on closed-forms?
3. Sound over-approximation evaluations on closed-forms.

What you can expect:

- ▶ Get a chance to work on relevant open problems of theoretical nature.
- ▶ You can always work in our student's room.
- ▶ We have a [very good coffee machine](#).

What we expect:

- ▶ Solid background in theoretical computer science. — ideally you have taken the lectures [Semantics and Verification](#) and [Probabilistic Programming](#)
- ▶ Solid mathematical skills in Algebra, Calculus and Stochastics — ideally maths as your minor / elective
- ▶ Passion and endurance for solving difficult (mathematical) problems.

Contact

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References

- [Kam19] Benjamin Lucien Kaminski, [Advanced weakest precondition calculi for probabilistic programs](#), Ph.D. thesis, RWTH Aachen University, Germany, 2019.
- [vdMPYW18] Jan-Willem van de Meent, Brooks Paige, Hongseok Yang, and Frank Wood, [An introduction to probabilistic programming](#), 2018.
- [Wil06] Herbert S. Wilf, [Generatingfunctionology](#), A. K. Peters, Ltd., USA, 2006.