
— Master's Thesis —

Distributional Certificates for probabilistic programs

What is it all about?

Probabilistic programs extend deterministic programs by a **random choice** about which code branch is executed next. They can be defined by the following grammar:

$$c ::= \text{skip} \mid x := a \mid \{c\}[p]\{c\} \mid c; c \mid \text{if } b \text{ then } c \text{ else } c \text{ end} \mid \text{while } b \text{ do } c \text{ end}.$$

Markov Decision Processes (MDPs) are models of nondeterministic and probabilistic systems. Formally, a **Markov decision processes** (MDP) is a tuple $\mathcal{M} = (S, \text{Act}, P)$ where S is a finite set of **states**, Act is a finite set of **actions**, and $P: S \times \text{Act} \times S \rightarrow [0, 1]$ is a **transition probability function** with the property that $\sum_{s' \in S} P(s, a, s') \in \{0, 1\}$ for all $s \in S$ and $a \in \text{Act}$. Recently, a notion of distributional certificates has been introduced for MDPs [ANZ25].

What is to be done?

The goals of this project are:

1. **Understand** and give examples for distributional certificates for MDPs
2. **Define** an equivalent notion of distributional certificates for **probabilistic programs**
3. If possible: **Prove** equivalence of the two notions

This list is of course non-exhaustive! The above suggestions may be changed, shortened and/or extended while we work on our project and gain more insights on how difficult the topic is.

What we expect:

- Solid background in theoretical computer science and maths – ideally you have already taken theoretical CS electives
- Passion and endurance for solving theoretical problems

What you can expect:

- Get a chance to work on relevant problems of both theoretical and practical nature
- You can work in the student room at our chair – we have a coffee machine, lots of tea and sometimes cookies :)

Apply

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Please introduce yourself briefly and say why you're interested in this topic!

References

[ANZ25] S. Akshay, Ouldouz Neysari, and Dorde Zikelic. Omega-regular verification and control for distributional specifications in mdps, 2025.