Bayesian Parameter Inference of Markov Population Model.

Master Thesis

Submitted by

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Contents

Acknowledgements

To the completement of this thesis, I would like to describe my deep

Abstract

something

Chapter 1

Introduction

1.1 Motivation

Markov population model.

In order to incorporate unknown features of the system, we introduce *parametric models*. Parameter synthesis is a relatively new research area [6]

This thesis is structured as follow.

1.2 Structure of the thesis

- **Chapter 1** introduces motivations and background for the research topic.
- **Chapter 2** describes the most important definitions and theoretical background. In this chapter, we defines Discrete-Time Markov Chain formally. A brief introduction to Bayesian Inference is also included.
- **Chapter 3** reviews the state-of-the-art works of other researchers on the problem of parameter synthesis.
- **Chapter 4** describes the method.
- **Chapter 5** describes the benchmark.
- **Chapter 6** conclusion and future work.

Chapter 2

Preliminaries

- probabilistic model checking
- parameter synthesis landscape
- bayesian inference of parameter

2.1 Probabilistic model checking

2.1.1 Discrete-time probabilistic models

Definition 2.1.1 (Discrete Time Markov Chain)**.** A Discrete Time Markov Chain (DTMC) is a tuple $(S, \mathbf{P}, S_{init}, AP, L)$ [1]

- S is a countable non-emty set of *states*
- $\mathbf{P} : S \times S \to [0, 1]$ is the *transition probability* function, s.t

$$\sum_{s' \in S} \mathbf{P}(s, s') = 1$$

- $S_{init} : S \to [0, 1]$ is the *initial distribution*, s.t

$$\sum_{s' \in S} S_{init}(s') = 1$$

- AP is a set of *atomic propositions*
- $L : S \to 2^{AP}$ is the labelling function on states.

2.1.2 Temporal properties on probabilistic models

Over CTL properties, we define the set of PCTL properties, in which we ask the probability to have a CTL property satisfied.

Definition 2.1.2 (PCTL syntax)**.** The syntax of PCTL is defined as follow

$$\Phi ::== \text{true} \mid a \mid \Phi \mid \Phi \wedge \Phi \mid \Phi \vee \Phi \mid P_{\sim p}[\phi]$$
$$\phi ::== X\Phi \mid \Phi U \Phi$$

2.1.3 Parametric model and parameter synthesis

2.2 Bayesian Inference

2.2.1 Bayes' theorem

2.2.2 Posterior conjugation

2.2.3 Metropolis-Hastings algorithm

2.2.4 Selection of prior distribution

The selection of prior distribution has strong effect on the result [what result specifically?] of a Bayesian inference [Citation needed].

2.3 Bayesian verification

Chapter 3

Related works

The current research progress on probabilistic model checking is studied thoroughly by Katoen and Baier et al [1]. Katoen et al. [6] briefly summarized important aspect of probabilistic model checking.

Polgreen et al [8] presents a method for bayesian inference of pMC parameters in

The definition and model checking of DTMC and pMC is studied by [1], [4], and [6].
Bayesian inference of pMC parameters is studied in [8] and [5]. In [8], the authors developed methods to synthesize parameters to satisfy a given set of PCTL properties. In [5], the authors presented methods to perform model checking of biological system using Bayesian statistic. The authors in [5] uses a Bayesian hypothesis test, where H_0 is the null hypothesis that the model satisfies a PCTL P, and alternative hypothesis H_1 is that the system does not satisfies P. Similar approach to the parameter estimation in this project is described by [3].
In this project, we use bee colony model semantics from [2]. The methods and implementation in this project is designed to extend the results of [2] and its tool *DiPS* [7]

Chapter 4

Framework for parameter synthesis.

4.1 Model construction

4.2 Framework

Chapter 5

Case study

5.1 Zeroconf

5.1.1 System description

Zero configuration protocol is as protocol widely used in the internet

5.1.2 Parametric model

5.1.3 Properties

5.1.4 Parameter synthesis

5.2 Defense bees

5.2.1 System description

5.2.2 Parametric model

5.2.3 Parameter synthesis

Chapter 6

Conclusion

6.1 Summary

In this thesis we

6.2 Future works

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