Bayesian parameter synthesis for markov population model.

Nhat-Huy Phung

University of Konstanz

April 8, 2021

Universität
Konstanz

Bayesian framework for data-informed parameter synthesis.

Model checking step

A property Φ is

- ▶ a bounded reachability property and
- ▶ specified by PCTL.

Checking a model $\mathcal{M}_\theta$ against Φ

- ▶ Rational fucntion evaluation
- ▶ Statistical model checking

Parameter synthesis step

Algorithm 1 Markov Chain Monte-Carlo with rational functions

 1: **procedure** MCMC-RF
 2:     Init θ from prior distribution $\pi(\theta)$.
 3:     $i \leftarrow 1$
 4:     **while** $i \leq N$ **do**
 5:         Draw θ_{cand} from $Q(\theta|\theta_1, \ldots, \theta_i)$
 6:         **if** $P(D_{obs}|\theta_{cand}) > P(D_{obs}|\theta_i)$ **then**
 7:             Accept θ_{cand} if $\mathcal{M}_{\theta_{cand}} \models \Phi$
 8:             $i \leftarrow i + 1$
 9:         **end if**
10:     **end while**
11:     Return $(\theta_1, \ldots, \theta_N)$
12: **end procedure**

Parameter synthesis step

Algorithm 2 Sequential Monte-Carlo with rational functions

1: **procedure** SMC-RF
2:     Init $\theta_1, \ldots, \theta_N$ from prior distribution $\pi(\theta)$.
3:     Set $w_i \leftarrow P(D_{obs}|\theta_i), 1 \leq i \leq N$
4:     **for** $t \in (1, \ldots, M)$ **do**
5:         Normalize $w_1^t, \ldots, w_N^t$
6:         Sample with replacement $\theta_1^t, \ldots, \theta_N^t$ from $\theta_1^{t-1}, \ldots, \theta_N^{t-1}$
7:         **for** $\theta_i \in (\theta_1^t, \ldots, \theta_N^t)$ **do**
8:             $\theta_i \leftarrow MCMC - RF(\theta_i), \ Q = F_i(\theta|\theta_1^{t-1}, \ldots, \theta_N^{t-1})$
9:         **end for**
10:    **end for**
11:    Return $(\theta_1, \ldots, \theta_N)$
12: **end procedure**

Parameter synthesis step

Algorithm 3 Sequential Monte-Carlo with simulations

1: **procedure** RF-SMC
2:     Init $\theta_1, \ldots, \theta_N$ from prior distribution $\pi(\theta)$.
3:     **for** $t \in (1, \ldots, M)$ **do**
4:         Sample with replacement $\theta_1^t, \ldots, \theta_N^t$ from $\theta_1^{t-1}, \ldots, \theta_N^{t-1}$
5:         **for** $\theta_i \in (\theta_1^t, \ldots, \theta_N^t)$ **do**
6:             Draw θ_{cand} from $F_i(\theta|\theta_1^{t-1}, \ldots, \theta_N^{t-1})$
7:             **if** Statistical Model Checking $\mathcal{M}_{\theta_{cand}} \models \Phi$ **then**
8:                 Simulate D_{sim} from $\mathcal{M}_{\theta_{cand}}$
9:                 **if** $Distance(D_{sim}, D_{obs} < \epsilon)$ **then**
10:                     Update $\theta_i \leftarrow \theta_{cand}$
11:                 **end if**
12:             **end if**
13:         **end for**
14:     **end for**
15:     Return $(\theta_1, \ldots, \theta_N)$
16: **end procedure**