Bayesian parameter synthesis for markov population model.

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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}_{θ} against Φ

- Rational fucntion evaluation
- Statistical model checking

Parameter synthesis step

Algorithm 1 Markov Chain Monte-Carlo with rational functions

```
1: procedure MCMC-RF
           Init \theta from prior distribution \pi(\theta).
 3:
           i \leftarrow 1
 4:
           while i \le N do
 5:
                 Draw \theta_{cand} from Q(\theta|\theta_1,\ldots,\theta_i)
 6:
                if P(D_{obs}|\theta_{cand}) > P(D_{obs}|\theta_i) then
 7:
                      Accept \theta_{cand} if \mathcal{M}_{\theta_{cand}} \models \Phi
 8:
                      i \leftarrow i + 1
 9.
                end if
10.
           end while
           Return (\theta_1, \ldots, \theta_N)
11:
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
            for t \in (1, ..., M) do
 4:
 5:
                 Normalize w_1^t, \ldots, w_N^t
                 Sample with replacement \theta_1^t, \dots, \theta_N^t from \theta_1^{t-1}, \dots, \theta_N^{t-1}
 6:
                 for \theta_i \in (\theta_1^t, \dots, \theta_N^t) do
 7:
                      \theta_i \leftarrow MCMC - RF(\theta_i), \ Q = F_i(\theta|\theta_1^{t-1}, \dots, \theta_N^{t-1})
 8:
 9.
                 end for
10:
            end for
            Return (\theta_1, \ldots, \theta_N)
11:
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
                 Sample with replacement \theta_1^t, \dots, \theta_N^t from \theta_1^{t-1}, \dots, \theta_N^{t-1}
 4:
 5:
                 for \theta_i \in (\theta_1^t, \dots, \theta_N^t) do
                       Draw \theta_{cand} from F_i(\theta|\theta_1^{t-1},\ldots,\theta_N^{t-1})
 6:
 7:
                       if Statistical Model Checking \mathcal{M}_{\theta_{cand}} \models \Phi then
 8:
                            Simulate D_{sim} from \mathcal{M}_{\theta_{cand}}
                            if Distance(D_{sim}, D_{obs} < \epsilon) then
 9:
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
```

References I