

DOBAD Package: simulation of BDI process conditional
on discrete observations

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Part I

Simulation of a Linear BDI Process, Conditional on Observing it at Discrete Times

We are demonstrating the use of the `DOBAD` package's function for conditionally simulating a birth-death process, using the methods of Doss et al. (2010). Call the process $\{X(t)\}_{t \in \mathbb{R}}$; we will simulate it conditional upon seeing data which is the value of the process at a finite number of discrete time points. That is, for times $0 = t_0, t_1, \dots, t_n$, we see the state of the process, $X(t_i)$. Thus the data D is 2 parts: a vector of the times $t_i, i = 0, \dots, n$ and a vector of states at each of those times, s_i , for $i = 0, \dots, n$ (where $X(t_i) = s_i$).

```
> library(DOBAD)
```

Generate a chain, the "truth" that we would not observe in practice:

```
> L <- .3; m <- .5;
> nu <- .4
> set.seed(112)
> unobservedChain <- birth.death.simulant(t=5, X0=11, lambda=.3, mu=.5, nu=.4);
> unobservedChain;
```

An object of class "BDMC"

Slot "states":

```
[1] 11 12 11 10 9 10 11 10 11 10 9 10 9 10 9 10 9 8 7 8 9 10 9 8 7
[26] 8 9 8 7 6 5 6 7 8 7 8 7 8 7 8 7 6 5 4
```

Slot "times":

```
[1] 0.0000000 0.1304171 0.1378384 0.1874095 0.3413327 0.4836734 0.5151733
```

```
[8] 0.5570117 0.7665553 0.9320789 1.0212908 1.1413929 1.1998740 1.2975232
[15] 1.3406924 1.3665537 1.3994869 1.6049192 1.6333970 1.7129540 1.7668332
[22] 1.8285686 1.8363130 1.9739581 1.9851389 2.0814101 2.0854210 2.3046697
[29] 2.4094295 2.5627537 2.6068091 3.1822596 3.3482861 3.3844540 3.4134403
[36] 3.4503969 3.4519932 3.9011731 4.1374942 4.2672352 4.3789622 4.5547798
[43] 4.6734574 4.7213272
```

Slot "T":

```
[1] 5
```

Then fix some “observation times” and “observe” the chain:

```
> times <- c(0, .21,.62,.73, 1.44, 1.95, 3.56, 4.17);
> obsData <- getPartialData(times, unobservedChain);
> obsData;
```

An object of class "CTMC_PO_1"

Slot "states":

```
[1] 11 10 10 10 9 9 7 7
```

Slot "times":

```
[1] 0.00 0.21 0.62 0.73 1.44 1.95 3.56 4.17
```

Now, we do a conditional simulation:

```
> nsims <- 2;
> condSims <- sim.condBD(N=nsims, bd.PO=obsData, L=L, m=m, nu=nu);
> condSims[1]
```

```
[[1]]
```

An object of class "BDMC"

Slot "states":

```
[1] 11 10 9 10 11 10 11 10 9 10 9 10 9 8 7 8 9 8 7 6 7
```

Slot "times":

```
[1] 0.00000000 0.05224893 0.44767799 0.57874166 0.76491147 0.86669301
[7] 0.99362847 1.17552882 1.41615881 1.64403070 1.68311572 1.75535090
[13] 1.91845847 2.06208393 2.10971694 2.29007387 2.31764070 2.59837720
[19] 2.70438486 3.88598190 4.08667118
```

Slot "T":

```
[1] 4.17
```

```
> condSims[2]
```

```
[[1]]
```

An object of class "BDMC"

Slot "states":

```
[1] 11 10 9 10 9 10 11 10 11 10 9 8 9 8 9 8 9 8 7 8 7 8 9 8 7
[26] 8 9 8 9 8 7 8 7 6 7
```

Slot "times":

```
[1] 0.00000000 0.0236948 0.3678200 0.3999958 0.4140034 0.4984449 0.5356764
[8] 0.6010608 0.8410324 0.9003820 0.9474968 1.0093066 1.3117696 1.4915494
[15] 1.5486054 1.7326306 1.9257244 2.0483914 2.0750409 2.1819917 2.5162341
[22] 2.5396541 2.6297680 2.6328050 2.6899456 2.9794553 3.0389456 3.0574857
[29] 3.2326328 3.2925628 3.4009558 3.7543826 4.0246196 4.0814779 4.1554435
```

Slot "T":

```
[1] 4.17
```

References

Doss, C., Suchard, M., Holmes, I., Kato-Maeda, M., and Minin, V. (2010). Great Expectations: EM Algorithms for Discretely Observed Linear Birth-Death-Immigration Processes.

Arxiv preprint arXiv:1009.0893 .