*Journal of Statistical Software*

*MMMMMM YYYY, Volume VV, Issue II.* *doi: 10.18637/jss.v000.i00*

# Discretizing the Distribution of a Population following a Discrete-time Markov Chain on a Continuous State Space

**Lealand Morin**
University of Central Florida

**Harry J. Paarsch**
University of Central Florida

**Abstract**

Package **discretizeCtsDTMC** creates a discrete approximation to a Markov process defined on a continuous state space in discrete time. Once the state space is discretized, **discretizeCtsDTMC** provides tools to estimate the transition matrices and analyze the Markov process. It is used to model a population of individuals, each following a continuous-state Markov process in discrete time.

We'll choose a better name later.

*Keywords*: Markov chain, Markov process, discretization.

## 1. Markov Chains in R

This article illustrates how to create a discrete approximation to the distribution function of a population of individuals following a Markov process defined on a continuous state space in discrete time. Once the state space is discretized, **discretizeCtsDTMC** provides tools to estimate the transition matrices and analyze the Markov process. It is used to model a population of individuals, each following a continuous-state Markov process in discrete time.

There are several R packages (R Core Team 2017) available for working with Markov processes. The packages **markovchain** (Spedicato, Kang, Yalamanchi, Yadav, and Cordon 2020) and **DTMCPack** (Nicholson 2013) provide tools for basic computations with Markov chains. The **mcmc** is desiggned for working with Monte Carlo Markov Chains. Packages **HMM** (Geyer and Johnson 2020) and **depmixS4** (Visser and Speekenbrink 2010) are designed for fitting Hidden Markov Models.

There are several packages aimed at specific applications of Markov chains. Some of these include packges designed for application in health care. There is **TPmsm** (Araújo, Meira-

Machado, and Roca-Pardiñas 2014) for estimating transition probabilities for 3-state progressive disease models and **heemod** (Filipović-Pierucci, Zarca, and Durand-Zaleski 2017) for applying Markov models to health care economic applications. Aimed at specific applications, some of these packages assume a considerable knowledge of the relevant subject matter and theory behind those applications.

The packages **msm** (Jackson 2011) and **SemiMarkov** (Król and Saint-Pierre 2015) are used for fitting multistate models to panel data, along with **mstate** (de Wreede, Fiocco, and Putter 2011) for survival analysis applications. These packages are designed to model discrete-state Markov processes in continuous time, with transitions taking place at a stochastic arrival times.

Figure 1: Caption goes here

## 2. Model

Harry, put all that good stuff here.

# 3. Example

A demonstration of analysis is shown in `discCtsDTMC_demo.R` and it serves as an example of what a typical session of model specification, estimation and testing can include. This procedure includes the following steps:

1. Organizing data
2. Choosing estimation options
3. Lag selection
4. Model estimation
5. Hypothesis testing

## 3.1. Organizing data

## 3.2. Choosing options

## 3.3. Lag-order selection

## 3.4. Model estimation

## 3.5. Hypothesis testing

# 4. Summary and discussion

This is a good package because...

# Computational details

The results in this paper were obtained using R 3.5.1. with the **discreteCtsDTMC** package Version 0.0.0.9000. R itself and all packages used are available from the Comprehensive R Archive Network (CRAN) at https://CRAN.R-project.org/.

The development version of this package is available by using the **devtools** package, with which the latest version can be installed by

`devtools::install_github(LeeMorinUCF/discreteCtsDTMC)`.

# Acknowledgments

To be amended: We are particularly grateful to .... For useful comments and helpful suggestions on earlier versions of this paper, we thank ....

## References

Araújo A, Meira-Machado L, Roca-Pardiñas J (2014). "**TPmsm**: Estimation of the Transition Probabilities in 3-State Models." *Journal of Statistical Software*, **62**(4), 1–29. URL http://www.jstatsoft.org/v62/i04/.

de Wreede LC, Fiocco M, Putter H (2011). "**mstate**: An R Package for the Analysis of Competing Risks and Multi-State Models." *Journal of Statistical Software*, **38**(7), 1–30. URL http://www.jstatsoft.org/v38/i07/.

Filipović-Pierucci A, Zarca K, Durand-Zaleski I (2017). "Markov Models for Health Economic Evaluation: The R Package **heemod**." *ArXiv e-prints*. R package version 0.13.0, 1702.03252.

Geyer CJ, Johnson LT (2020). ***mcmc**: Markov Chain Monte Carlo*. R package version 0.9-7, URL https://CRAN.R-project.org/package=mcmc.

Jackson CH (2011). "Multi-State Models for Panel Data: The **msm** Package for R." *Journal of Statistical Software*, **38**(8), 1–29. URL http://www.jstatsoft.org/v38/i08/.

Król A, Saint-Pierre P (2015). "**SemiMarkov**: An R Package for Parametric Estimation in Multi-State Semi-Markov Models." *Journal of Statistical Software*, **66**(6), 1–16. URL http://www.jstatsoft.org/v66/i06/.

Nicholson W (2013). ***DTMCPack**: Suite of functions related to discrete-time discrete-state Markov Chains*. R package version 0.1-2, URL https://CRAN.R-project.org/package=DTMCPack.

R Core Team (2017). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Spedicato GA, Kang TS, Yalamanchi SB, Yadav D, Cordon I (2020). *The **markovchain** Package: A Package for Easily Handling Discrete Markov Chains in R*. R package version 0.8.5, URL https://CRAN.R-project.org/package=markovchain.

Visser I, Speekenbrink M (2010). "**depmixS4**: An R Package for Hidden Markov Models." *Journal of Statistical Software*, **36**(1), 1–21. URL http://www.jstatsoft.org/v36/i07/.

**Affiliation:**

Lealand Morin
Department of Economics
University of Central Florida
E-mail: Lealand.Morin@ucf.edu

Harry J. Paarsch
Department of Economics
University of Central Florida
E-mail: Harry.Paarsch@ucf.edu

*Journal of Statistical Software* http://www.jstatsoft.org/
published by the Foundation for Open Access Statistics http://www.foastat.org/
MMMMMM YYYY, Volume VV, Issue II *Submitted:* yyyy-mm-dd
doi:10.18637/jss.v000.i00 *Accepted:* yyyy-mm-dd