Package: moveMMPP (via r-universe)

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Title Fit Continuous-Time Markov Modulated Poisson Process Movement Models to Animal Resight Data

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Description Using animal resight data, the package functions allow the user to estimate movement rates and resource selection using a continuous-time Markov chain movement model.

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Depends Matrix

Imports dplyr, sf, spdep, tidyr, units, lubridate, optimx, numDeriv, terra, rARPACK

LinkingTo Rcpp, RcppArmadillo, expQ2

Remotes dsjohnson/expQ2

NeedsCompilation yes

Repository https://dsjohnson.r-universe.dev

RemoteUrl https://github.com/dsjohnson/moveMMPP

RemoteRef HEAD

RemoteSha 50e71282da01aae7525841c6582886be21f05657

Contents

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arg_funs   *Define specifics for model structure and fitting control*

Description

Define specifics for model structure and fitting control

Usage

```
mmpp_model(form = ~1, link = "soft_plus", a = 1, L = 0, U = 0)

mmpp_control(
  lambda = mmpp_model(),
  q_r = mmpp_model(),
  q_m = mmpp_model(),
  struc = "mult",
  norm = TRUE
)
```

Arguments

form	Model formula for MMPP model components, residency, movement, and detection
link	A link function for the model component. One of `"soft_plus"`, `"log"`, or `"logit"`.
a	Scale parameter for the `"soft_plus"` link function. Ignored for `link="log"` or `"logit"`. The a parameter determines the approximation to a hard plus function, i.e., as a becomes large the soft plus function converges to $g^{-1}(x) = \max(0,x)$. For this specification, a must be greater than or equal to 1.
L	Lover bound for general logit link.
U	Upper bound for general logit link.
lambda	A named list for the detection portion of the model. See \link{mmpp_model}
q_r	A named list for the residency model. Must contain elements: `form`, `link`, and a. The easiest way to construct this is the \link{mmpp_model} function.
q_m	A named list for the movement portion of the model. See `q_r` and \link{mmpp_model}.

struc	The form of the rate matrix entries. Can be one of: "mult" for residency times movement, i.e., q_ij = q_r(i) * pi_m(i,j) or "add" for a model of the form q_ij = q_r(i) + pi_m(i,j).
norm	Should the movement portion be adjusted to sum to 1. This is the parameterization suggested by Hewitt et al. (2023).

References

Hewitt, J., Gelfand, A. E., & Schick, R. S. (2023). Time-discretization approximation enriches continuous-time discrete-space models for animal movement. The Annals of Applied Statistics, 17:740-760.

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dm_matrix	*Create sparse representations of design matrices for movement and resight models*

Description

Create sparse representations of design matrices for movement and resight models

Usage

```
dm_lambda(formula, ddl)

dm_q_m(formula, ddl)

dm_q_r(formula, ddl)
```

Arguments

formula	An R formula object for the paramter vector.
ddl	Design data list

Details

This function is not designed for end-users but is exported for posterity.

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fit_mmpp   *Fit MMPP movement model to resight data*

Description

Fit MMPP movement model to resight data

Usage

```
fit_mmpp(
  data,
  ddl,
  model_parameters = mmpp_control(),
  pen_fun = NULL,
  hessian = TRUE,
  start = NULL,
  method = "nlminb",
  fit = TRUE,
  eq_prec = 1e-08,
  debug = 0,
  ...
)
```

Arguments

data	A processed data frame produced by the function [process_data](#)
ddl	A design data list produced by the function [make_design_data](#).
model_parameters	
	Model formula for the detection and movement portions of the MMPP model. See \link{mmpp_control}
pen_fun	An optional penalty function. Should be on the scale of a log-prior distribution.
hessian	Logical. Should the Hessian matrix be calculated to obtain the parameter variance-covariance matrix.
start	Optional starting values for the parameter must be a list of the form list(beta_l=c(), beta_q_r=c(), beta_q_r=c()).
method	Optimization method. See [optimr](#)
fit	Logical. Should the likelihood be optimized?
eq_prec	Precision of the matrix exponential approximation.
debug	Integer from 1-4. Opens browser() at various points in the function call. Mostly for package developers.
...	Additional arguments passed to the optimization function [optimr](#) from the [optimx-package](#).

Details

Two model forms are available `list(lambda=list(form=~1, offset=NULL), q=list(form=~1,`
`offset=~log(1.num_neigh)))`. For the q model you must use `offset=0` to not have one. If
it is left off, `offset=~log(1.num_neigh)))` will be used. To use the movement rate form of
Hewitt et al. (2023), one must use, e.g., `q = list(res_form = ~from_var, mov_form=~to_var,`
`offset=...)`, where `from_var` is a variable

Author(s)

Devin S. Johnson

References

Hewitt, J., Gelfand, A. E., & Schick, R. S. (2023). Time-discretization approximation enriches
continuous-time discrete-space models for animal movement. The Annals of Applied Statistics,
17:740-760.

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get_betas	*Summarize beta parameter values*

Description

Takes fitted model and produces a summary of the beta estimates.

Usage

```
get_betas(par, V = NULL, data_list)
```

Arguments

par	Model estimated parameters
V	Optional variance-covariance matrix for the parameters. If none is given no standard errors will be provided for the real parameter estimates
data_list	The data list from a fitted model object

Author(s)

Devin S. Johnson

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get_lim_ud   *Get the limiting utilization distribution of the CTMC movement pro-*
                                     cess

Description

Get the limiting utilization distribution of the CTMC movement process

Usage

```
get_lim_ud(fit = NULL, hpd = NULL, method = "lu", ...)
```

Arguments

`fit`	A moveMMPP fitted model object from \link{fit_mmpp_dir}.
`hpd`	A vector of probabilities. Will return columns with highest probability area for each specified probability. E.g., hpd=c(0.5, 0.95) will return 2 extra columns with 50 and 95% HPD densities.
`method`	Method used for eigen decomposition. One of "lu" or "arpack".
`...`	Extra arguments to pass to eigs

Author(s)

Devin S. Johnson

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get_Q   *Get movement transition matrix from fitted moveMMP object*

Description

Get movement transition matrix from fitted moveMMP object

Usage

```
get_Q(fit, sparse = TRUE)
```

Arguments

`fit`	A moveMMPP fitted model object from \link{fit_mmpp}.
`sparse`	Logical. Should the matrix be returned in a sparse format from the Matrix package. Defaults to sparse = TRUE.

Author(s)

Devin S. Johnson

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make_design_data   *Produce design data for use in fitting MMPP movement models*

Description

Produce design data for use in fitting MMPP movement models

Usage

```
make_design_data(
  sighting_data = NULL,
  cell_data,
  rast_mask = NULL,
  debug = 0,
  ...
)
```

Arguments

sighting_data	—.
cell_data	—.
rast_mask	Raster mask for inaccessible cells when `cell_data` is of type `SpatRaster` from the `terra` package. This is ignored if `cell_data` is an `POLYGON` data frame from the `sf` package.
debug	Debugging level: 1-3 mainly for package developers.
...	Ignored arguments.

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make_sim_dm   *Create model data necessary for MMPP simulation*

Description

Create model data necessary for MMPP simulation

Usage

```
make_sim_dm(ddl, model_parameters = mmpp_control())
```

Arguments

ddl	Design data list created from [make_design_data](#).
model_parameters	
	Model formula for the detection and movement portions of the MMPP model.

Author(s)

Devin S. Johnson

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make_sim_par   *Create Q and L matrices for MMPP simulation*

Description

Create Q and L matrices for MMPP simulation

Usage

```
make_sim_par(sim_dm, par)
```

Arguments

sim_dm	A list of design matrices resulting from a call to make_sim_dm
par	A list corresponding to the coefficients for lambda, Q_m, and Q_r. It must match the lengths in sim_dm$par_map.

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mmpp_ll   *Evaluate movement MMPP log-likelihood*

Description

Evaluate movement MMPP log-likelihood

Usage

```
mmpp_ll(par, data_list, debug = 0, ...)
```

Arguments

par	Parameter vector
data_list	List of required data objects to evaluate likelihood
debug	For developers only, leave in the default setting.
...	Extra wiggle room for ignored arguments.

Author(s)

Devin S. Johnson

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process_data   *Process MMPP movement detection data for model fitting*

Description

Process MMPP movement detection data for model fitting

Usage

```
process_data(data, cell_name = NULL, aug_timestamp = NULL, time_unit = "days")
```

Arguments

data	Detection data. Must contain columns `timestamp` and `cell` to indicate time and place of detection. Also, must contain column named `id` to indicate different individuals.
cell_name	Character. The column name in the data representing the discrete spatial cells on which the animal moves.
aug_timestamp	Augmented times for modeling temporally dynamic movement or detection. See 'Details'
time_unit	—.

Details

(`aug_timestamp` can be either passed as a separate vector of POSIXct or `process_data` can derive a sequence of regularly spaced augmentation times from the original data. This is specified by providing a character string that corresponds to the by argument of the seq.POSIXt function (e.g. '1 year', '1 month').

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sim_mmpp   *Simulate a Markov Modulated Poisson Process*

Description

Simulate a Markov Modulated Poisson Process

Usage

```
sim_mmpp(n = 1, max_time, min_obs, Q, L, start_loc = NULL)
```

Arguments

`n`	Number of independent simulations
`max_time`	...
`min_obs`	...
`Q`	A movement rate matrix
`L`	A detection rate vector
`start_loc`	Starting location of the path. If not specified, the limiting distribution implied by `Q` will be used to randomly select a starting location.

Author(s)

Devin S. Johnson

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