Package: m2b (via r-universe)

Title Movement to Behaviour Inference using Random Forest

Version 1.0

Description Prediction of behaviour from movement characteristics
using observation and random forest for the analyses of
movement data in ecology. From movement information (speed,
bearing...) the model predicts the observed behaviour
(movement, foraging...) using random forest. The model can then
extrapolate behavioural information to movement data without
direct observation of behaviours. The specificity of this
method relies on the derivation of multiple predictor variables
from the movement data over a range of temporal windows. This
procedure allows to capture as much information as possible on
the changes and variations of movement and ensures the use of
the random forest algorithm to its best capacity. The method is
very generic, applicable to any set of data providing movement
data together with observation of behaviour.

VignetteBuilder knitr

Depends R (>= 3.3.0)

Imports geosphere, caTools, ggplot2, randomForest, e1071, caret,
methods, graphics, stats, utils

Suggests adehabitatLT, moveHMM, knitr, DiagrammeR, rmarkdown

License GPL-3

URL https://github.com/ldbk/m2b

Encoding UTF-8

LazyData true

Date 2017-04-03

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RoxygenNote 6.0.1

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

RemoteUrl https://github.com/ldbk/m2b

RemoteRef HEAD

RemoteSha 9fc5404d1de8410953d792b817b02882a9925d5c

Contents

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dxyt   *internal function*

Description

internal function

Usage

```
dxyt(xyt)
```

Arguments

xyt   xyt parameters

Author(s)

Laurent Dubroca

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dxyt2   *internal function*

Description

internal function

Usage

```
dxyt2(dxyt, winsize = seq(3, 13, 2), idquant = seq(0, 1, 0.25))
```

Arguments

dxyt   A parameter

winsize   A parameter

idquant   A parameter

Author(s)

Laurent Dubroca

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extractRF   *Extract the random forest model from an xytb object*

Description

The random forest model is extracted from the xytb object to a randomForest object.

Usage

```
extractRF(xytb)
```

Arguments

xytb   an xytb object with a model.

Value

a randomForest object as defined by the randomForest package.

Author(s)

Laurent Dubroca

See Also

See randomForest

Examples

```
#track_CAGA_005 is dataset
#generate a complete xytb object with derived (over moving windows of 3, 5
#and 9 points, with quantile at 0, 50 and 100%) and shifted information on 10
#and 100 points
xytb<-xytb(track_CAGA_005,"a track",c(3,5,9),c(0,.5,1),c(10,100))
#compute a random forest model to predict behaviour (b, where -1 is
#unobserved behaviour) using the derived
#parameters ("actual")
xytb<-modelRF(xytb,"actual",nob="-1",colin=TRUE,varkeep=c("v","thetarel"),zerovar=TRUE)
#extract the model
modRF<-extractRF(xytb)
# results from randomForest package:
print(modRF)
plot(modRF)
```

---

ltraj2xytb *ltraj object conversion to xytb object*

Description

The function converts a ltraj object to a xytb object (see https://CRAN.R-project.org/package=adehabitatLT and xytb-class).

Usage

```
ltraj2xytb(ltraj, desc = "ltraj object convert to xytb")
```

Arguments

ltraj   A ltraj object

desc   General descriptor of the data

Value

A xytb object with behavioural information taken from the infolocs (aka ltraj object should correspond the an export of xytb object in ltraj).

Author(s)

Laurent Dubroca

Examples

```
#track_CAGA_005 is a dataset
xytb<-xytb(track_CAGA_005,"a track",3,.5)
ltraj<-xytb2ltraj(xytb)
xytb2<-ltraj2xytb(ltraj,"a track")
```

---

m2b *Movement to behaviour package*

Description

A package to infer behaviour and social interaction from movement data

Details

Animal behaviour, including social interactions, are fundamental to the field of ecology. Whereas the direct observation of animal behaviour is often limited due to logistical constraints, collection of movement data have been greatly facilitated through the development of bio-logging. Animal movement data obtained through tracking instrumentation may potentially constitute a relevant proxy to infer animal behaviour. This is, however, based on the premise that a range of movement patterns can be linked to specific behaviours.

Statistical learning constitutes a number of methods that can be used to assess the link between given variables from a fully informed training dataset and then predict the values on a non-informed variable. We chose the random forest algorithm for its capacity to deal with imbalanced data (particularly relevant for behavioural data), its high prediction accuracy and its ease of implementation (@breiman2001b, @chen2004). The strength of random forest partly relies in its ability to handle a very large number of variables. Hence, our methodology is based on the derivation of multiple predictor variables from the movement data over various temporal scales, in order to capture as much information as possible on the changes and variations of movement.

In this package we developed a method to link the movement patterns of animals with their behaviour, using the random forest algorithm. The specificity of this method relies on the derivation of multiple predictor variables from the movement data over a range of temporal windows. This procedure allows to capture as much information as possible on the changes and variations of movement and ensures the use of the random forest algorithm to its best capacity. The method is very generic, applicable to any dataset providing movement data together with observation of behaviour.

---

modelRF *xytb randomForest function*

Description

Build a random forest model on a xytb object, predicting behaviour using only the variables calculated at the time of observation (type 'actual') or using the variable shifted backwards in time (type 'shifted'). Parameters are transfered to the randomForest or the rfcv functions of the randomForest package if needed.

Usage

```
modelRF(xytb, type = c("actual", "shifted"), nob = "-1", colin = TRUE,
  varkeep = c("v", "dist", "thetarel"), zerovar = TRUE, rfcv = FALSE,
  ntree = 501, importance = TRUE, ...)
```

Arguments

xytb	an xytb object
type	character -actual or shifted- use actual data or shifted one to build the model
nob	character. Define the unobserved value of the behaviour (and where prediction are done)
colin	boolean - remove colinearity among predictors (see the caret package for more details)
varkeep	character vector - the variables names in this vector are keeped in the model even if colinearity is found (usefull to keep 'classical' parameters and to help interpretation)
zerovar	boolean - remove near zero variance predictor (see the caret package for more details)
rfcv	boolean - run a random forest cross-validation for feature selection procedure for xybt (this call the rfcv fonction for the model). This function shows the cross-validated prediction performance of models with sequentially reduced number of predictors (ranked by variable importance) via a nested cross-validation procedure for a xytb object.
ntree	number of trees in the random Forest (see the randomForest package for more details)
importance	boolean (see the randomForest package for more details)
...	other arguements passed to randonForest or rfcv

Author(s)

Laurent Dubroca and Andréa Thiebault

See Also

See randomForest and rfcv

Examples

```
#track_CAGA_005 is dataset
#generate a complete xytb object with derived (over moving windows of 3, 5
#and 9 points, with quantile at 0, 50 and 100%) and shifted information on 10
#and 100 points
xytb<-xytb(track_CAGA_005,"a track",c(3,5,9),c(0,.5,1),c(10,100))
#compute a random forest model to predict behaviour (b, where -1 is
#unobserved behaviour) using the derived
#parameters ("actual")
xytb<-modelRF(xytb,"actual",nob="-1",colin=TRUE,varkeep=c("v","thetarel"),
```

```
zerovar=TRUE)
## Not run:
#cross-validation for the same model (time consuming !)
xytb<-modelRF(xytb,"actual",nob="-1",colin=TRUE,varkeep=c("v","thetarel"),
zerovar=TRUE,rfcv=TRUE)

## End(Not run)
```

---

plot	*xytb plot method*

Description

plot method for xytb object

Usage

```
## S4 method for signature 'xytb,missing'
plot(x, y)
```

Arguments

x   An xytb object.

y   empty

Value

a plot

---

resB	*Representation of the predicted vs observed behaviour of an xytb object*

Description

Representation of the predicted vs observed behaviour of an xytb object

Usage

```
resB(xytb, type = "time", nob = "-1")
```

Arguments

`xytb`	an xytb object with predicted behaviour.
`type`	• `time`: plot results in time. • `space`: plot results in space. • `density`: plot results in space, adding density surface by behaviour.
`nob`	character. Define the unobserved value of the behaviour (and where prediction are done)

Value

a ggplot

Author(s)

Laurent Dubroca

See Also

See randomForest

Examples

```
## Not run:
#track_CAGA_005 is dataset
#generate a complete xytb object with derived (over moving windows of 3, 5
#and 9 points, with quantile at 0, 50 and 100%) and shifted information on 10
#and 100 points
xytb<-xytb(track_CAGA_005,"a track",c(3,5,9),c(0,.5,1),c(10,100))
#compute a random forest model to predict behaviour (b, where -1 is
#unobserved behaviour) using the derived
#parameters ("actual")
xytb<-modelRF(xytb,"actual",nob="-1",colin=TRUE,varkeep=c("v","thetarel"),
zerovar=TRUE,rfcv=FALSE,step=.9)
#behaviour results:
resB(xytb,type="time",nob="-1")
resB(xytb,type="space",nob="-1")
resB(xytb,type="density",nob="-1")

## End(Not run)
```

---

resRF	*Random forest model outputs for a xytb object*

Description

Diagnostic plots and tables for the random forest model used to predict behaviour on a xytb objecti (random forest convergence plot, variable importance plot, cross-validation plot, confusion matrix of the observed vs predicted behaviours).

Usage

```
resRF(xytb, type = "rf")
```

Arguments

xytb   An xytb object with a model.

type   • rf: plot of the OOB versus the number of trees (see randomForest).

        • importance: importance plot (see varImpPlot).

        • rfcv: plot of the cross-validated prediction performance of models with sequentially reduced number of predictors (see rfcv).

        • confusion: confusion matrix between observed and predicted behaviours (see confusionMatrix).

Value

plots or tables.

Author(s)

Laurent Dubroca

See Also

See randomForest

Examples

```
## Not run:
#track_CAGA_005 is dataset
#generate a complete xytb object with derived (over moving windows of 3, 5
#and 9 points, with quantile at 0, 50 and 100%) and shifted information on 10
#and 100 points
xytb<-xytb(track_CAGA_005,"a track",c(3,5,9),c(0,.5,1),c(10,100))
#compute a random forest model to predict behaviour (b, where -1 is
#unobserved behaviour) using the derived
#parameters ("actual")
xytb<-modelRF(xytb,"actual",nob="-1",colin=TRUE,varkeep=c("v","thetarel"),
zerovar=TRUE,rfcv=TRUE,step=.9)
#modelling results
resRF(xytb,type="rf")
resRF(xytb,type="importance")
resRF(xytb,type="rfcv")
resRF(xytb,type="confusion")

## End(Not run)
```

---

shiftvalue   *internal function*

Description

internal function

Usage

```
shiftvalue(dat0, mov = seq(5, 250, 5))
```

Arguments

dat0   A parameter

mov   A parameter

Author(s)

Laurent Dubroca

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track_CAGA_005   *Data collected from a cape gannet track (*Morus capensis*, Lichtenstein 1823), breeding on Bird Island (Algo Bay, South Africa) in december 2010.*

Description

Tracking data recorded with a GPS device (i-GotU GT-600, Mobile Action Technology Inc., Taipei, Taiwan). Regular step duration at 5s. Behaviour data recorded with a video camera (Camsports nano, CamsportsTM, Estrablin, France). Observations of taking off, landing and diving, from wich three behavioural states were infered: flying, sitting on the water, diving. Recording during the first 90 min (short autonomy of camera) of the trip.

Usage

```
track_CAGA_005
```

Format

Tracking data

Columns:

x = longitude in decimal degrees

y = latitude in decimal degrees

t = time in POSIXct

b = behaviour observed on video data (3:flying, 2:sitting on water, 1:diving ,-1:no data)

id = individual id

Source

Andréa Thiebault

---

xytb	*xytb class constructor*

Description

The methods to build an xytb object (see xytb-class for the class description).

Usage

```
xytb(object, desc, winsize, idquant, move, ...)

## S4 method for signature 'missing,missing,ANY,ANY,ANY'
xytb(desc = "null xybt object")

## S4 method for signature 'data.frame,character,ANY,ANY,ANY'
xytb(object, desc, winsize,
  idquant, move, ...)

## S4 method for signature 'data.frame,character,vector,vector,ANY'
xytb(object, desc, winsize,
  idquant, move, ...)

## S4 method for signature 'data.frame,character,vector,vector,vector'
xytb(object,
  desc = "unknow track", winsize = seq(3, 13, 2), idquant = seq(0, 1,
  0.25), move = c(5, 10), ...)
```

Arguments

object   a data frame with 5 columns

id	individual id	character
x	longitude	decimal degree
y	latitude	decimal degree
t	date and time	POSIXct
b	behaviour	character

desc   vector of character describing the dataset

winsize   a numerical vector giving the length of the windows used to calculate moving standard deviation, average, mad and quantile for the speed (v), the distance (dist) and the relative angle (thetarel).

idquant	a numerical vector giving the quantiles to be calculated. For example if idquant=c(0,0.25,.5,1), the quantiles at 0% (min), 25% (first quartile), 50% (median) and 100% (max) will be calculated.
move	a numerical vector providing the shift used to computed parameters back in time. For example if move=c(5,10,100), the parameters will be shifted backward by 5, 10 and 100 locations. Optional.
...	part of the generic definition

Value

an xytb object

Methods' signature

- `xytb()`: generate an empty xytb object.

- `xytb(data.frame,character vector)`: generate an xytb object with track information (only slot desc, xyt and b are computed).

- `xytb(data.frame,character vector,numerical vector,numerical vector,numerical vector)`: generate an xytb object with track information (slots desc, xyt, b) and derived information dxyt and befdxyt. dxyt contains statistical derivatives of speed, distance and relative angle calculated on moving windows given by the winsize parameters. Statistical derivatides are standard deviation, mean, median absolute deviation and quantiles. Quantiles are defined by the idquant parameters. befdxyt contains dxyt values shifted back in time according to the move parameters.

Author(s)

Laurent Dubroca

Examples

```
#generate an empty xytb object
xytb()
#generate an xytb object with track information only
#track_CAGA_005 is a dataset
simplexytb<-xytb(track_CAGA_005,"a track")
#generate a complete xytb object with derived (over moving windows of 3, 5
#and 9 points, with quantile at 0, 50 and 100%) and shifted information on 10
#and 100 points
xytb<-xytb(track_CAGA_005,"a track",c(3,5,9),c(0,.5,1),c(10,100))
```

xytb-class   *xytb class definition*

Description

xytb is a trajectory object with observed behaviour

Slots

desc a character vector. A description of the data.

xyt a data frame of the track information. One row is one position described by 11 variables :

id:	individual id
t:	time in POSIXct
x:	longitude
y:	latitude
dt:	time (s) between the current location and the next one
dist:	distance (m) between the current location and the next one calculated using the Vincenty ellipsoid method. See dist
v:	speed (m.s^-1)
dx:	the increase of the move in the x direction.
dy:	the increase of the move in the y direction.
theta:	the angle between each move and the x axis.
thetarel:	the turning angle between successive moves.

This slot is very similar to the ltraj class of the adehabitatLT package.

b a data frame of the observed behaviour related to the track. One row is one behavioural observation related to the track described by 3 variables:

id:	individual id
t:	time in POSIXct
b:	observed behaviour (character)

dxyt a data frame of the derived variables from the track.

befdxyt a data frame of the derived variables shifted back in time.

model a randomForest model (see randomForest).

rfcv the output of the cross-validation procedure (see rfcv).

predb a data frame of the predicted behaviour using the random forest model of the slot model. 3 variables :

id:	individual id
t:	time in POSIXct
b:	observed behaviour (character)

Author(s)

Laurent Dubroca

---

xytb2hmm   *xytb object conversion to moveHMM object*

Description

The function converts a xytb object to a moveHMM dataframe (see https://CRAN.R-project.org/package=moveHMM and prepData).

Usage

```
xytb2hmm(xytb)
```

Arguments

xytb   A xytb object

Value

A dataframe ready to be used by the function of the 'moveHMM'

Author(s)

Laurent Dubroca

Examples

```
#track_CAGA_005 is a dataset
xytb<-xytb(track_CAGA_005,"a track",3,.5)
xyhmm <-xytb2hmm(xytb)
#then you can use moveHMM functions
if(requireNamespace("moveHMM")){
 plot(xyhmm)
}
```

| xytb2ltraj | *xytb class conversion to ltraj object* |

Description

The function converts a xytb object to a ltraj object as defined in the adehabitatLT package (see
https://CRAN.R-project.org/package=adehabitatLT as.ltraj).

Usage

```
xytb2ltraj(xytb)
```

Arguments

xytb   An xytb object

Value

A ltraj object with behavioural information recorded in the infoloc

Author(s)

Laurent Dubroca

Examples

```
#track_CAGA_005 is a dataset
xytb<-xytb(track_CAGA_005,"a track",3,.5)
ltraj<-xytb2ltraj(xytb)
#all adehabitatLT function are now available
summary(ltraj)
plot(ltraj)
```

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