Package ‘m2b’

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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.

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**dxyt**  
*internal function*

**Description**

*internal function*

**Usage**

`dxyt(xyt)`

**Arguments**

- `xyt`  
  xyt parameters

**Author(s)**

Laurent Dubroca
dxyt2

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

extractRF

Description
Extract the random forest model from an xytb 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 \texttt{randomForest}

Examples

\begin{verbatim}
#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)
\end{verbatim}

\begin{verbatim}
ltraj2xytb  ltraj object conversion to xytb object
\end{verbatim}

Description

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

Usage

\begin{verbatim}
ltraj2xytb(ltraj, desc = "ltraj object convert to xytb")
\end{verbatim}

Arguments

\begin{itemize}
  \item \texttt{ltraj} A ltraj object
  \item \texttt{desc} General descriptor of the data
\end{itemize}

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

```r
#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.

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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 transferred 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 kepted in the model even if collinearity 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 xytb (this call the rfcv function 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.
nrree          number of trees in the random Forest (see the randomForest package for more details)
importance    boolean (see the randomForest package for more details)
...            other arguments passed to randomForest 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"),
# 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**

```r
## 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**

```r
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

```r
## 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)
```

Description

Diagnostic plots and tables for the random forest model used to predict behaviour on a xytb object (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)
Description

internal function

Usage

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

Arguments

dat0 A parameter
mov A parameter

Author(s)

Laurent Dubroca

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 which three behavioural states were inferred: 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, ...)`

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

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

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

```r
## 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`  
  - `x`  
  - `y`  
  - `t`  
  - `b`

- **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  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 distVincentyEllipsoid)
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

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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