Package 'RRMLRfMC'

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Type Package

Title Reduced-Rank Multinomial Logistic Regression for Markov Chains

Version 0.4.0

Description Fit the reduced-rank multinomial logistic regression model for Markov chains developed by Wang, Abner, Fardo, Schmitt, Jicha, Eldik and Kryscio (2021)<doi:10.1002/sim.8923> in R. It combines the ideas of multinomial logistic regression in Markov chains and reduced-rank. It is very useful in a study where multi-states model is assumed and each transition among the states is controlled by a series of covariates. The key advantage is to reduce the number of parameters to be estimated. The final coefficients for all the covariates and the p-values for the interested covariates will be reported. The p-values for the whole coefficient matrix can be calculated by two bootstrap methods.

License GPL-2

Encoding UTF-8

LazyData true

Imports nnet

Depends R (>= 3.5.0)

RoxygenNote 7.1.1

Suggests rmarkdown, knitr

NeedsCompilation no

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Contents

`Aupdate` *Aupdate*

Description

This function is used to update A matrix

Usage

```
Aupdate(Dfix, Gamma, Adata, R, p, q, I, iniA, eps, refA)
```

Arguments

`Dfix`	the coefficient matrix for study covariates
`Gamma`	the G matrix value
`Adata`	the dataset
`R`	the rank of reduced rank model
`p`	the number of covariates in the dimension reduction
`q`	the numbne of study covariates
`I`	a U by U incidence matrix with elements; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
`iniA`	initial value for the iteration
`eps`	the tolerance for convergence, default is 10^-5
`refA`	a vector of reference categories

Value

a list of outputs:

- NewA: the updated A matrix
- loglikeA: the loglikelihood when updating A

cogdat *Cognitive Dataset*

Description

A dataset containing the states and covariates of 649 participants enrolled in the BRAiNS cohort at the University of Kentucky's Alzheimer's Disease Research Center.

Usage

```
cogdat
```

Format

A data frame with 6240 rows and 14 columns:

ID used to denote the participants; from 1 to 649

visitno used to denote the visit number for each participant

prstate denote the previous state

custate denote the current state

bagec baseline age (centered at age 72)

famhx family history of dementia

HBP self reported high blood pressure

apoe4 at least one Apolipoprotein-E (APOE) gene $\epsilon 4$ allele

smk1 cigarette smoking level (none versus < 10)

smk2 cigarette smoking level (11-19)

smk2 cigarette smoking level (>= 20 pack years))

lowed low education

headinj self reported head injury

derivativeB *derivativeB*

Description

This function is used to calculate the loglikelihood with a given matrix B=AG

Usage

```
derivativeB(B, I, zy, refd)
```

Arguments

B	a numeric coefficient matrix
I	U by U incidence matrix with elements; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
zy	the variable values for a given observation
refd	a vector of reference categories

Value

loglikelihood

---

derivatives *derivatives*

Description

This function is used calculate the derivative values (first and second derivatives for Newton-Raphson method) and loglikelihood when updating A

Usage

```
derivatives(A, Gamma, Dmat, I, zy, refA)
```

Arguments

A	matrix with value from previous iteration
Gamma	G matrix values
Dmat	the coefficient matrix for the fixed variables,
I	a U by U incidence matrix with elements; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
zy	the variable values for a given observation
refA	a vector of reference categories

Value

a list of outputs:

- ird: the first derivative value
- secd: the second derivative value
- loglike: the loglikelihood

expand *expand*

Description

This function is used to expand the Y(category) to a indicator vector

Usage

```
expand(pri, curr, I, refE)
```

Arguments

pri	the prior state
curr	the current state
I	a U by U incidence matrix with elements; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
refE	a vector with the reference categories

Value

ry: a indicator vector

Gupdate *Gupdate*

Description

This function is used to update G matrix

Usage

```
Gupdate(A, Gdata, p, q, I, refG)
```

Arguments

A	numeric matrix
Gdata	the dataset used to update G
p	the number of covariates in the dimension reduction
q	the numbne of study covariates
I	a U by U incidence matrix with elements; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
refG	a vector of reference categories

Value

a list of outputs:

- NewG: the updated G matrix
- loglikeK: the loglikelihood when updating G
- sderr: standard errors for the coefficient matrix

`norm` *norm*

Description

This function is used to normalize a vector to have unit length

Usage

```
norm(x)
```

Arguments

`x`	a numeric vector

Value

a normalized vector with length 1

`rrmultinom` *rrmultinom*

Description

This function is used to fit the reduced rank multinomial logistic regression for markov chain

Usage

```
rrmultinom(I, z1 = NULL, z2 = NULL, T, R, eps = 1e-05, ref = NULL)
```

Arguments

I	a U by U incidence matrix with elements; U is number of states; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
z1	a n by p matrix with covariates involved in the dimension reduction(DR), n is the number of subjects, p is the number of covariates involved in DR
z2	a n by q matrix with study covariates (not in dimension reduction), q is the number of study covariates
T	a M by 3 state matrix, • the first column is a subject number between 1,..,n; • the second column is time; • the third column is the state occupied by subject in column 1 at time indicated in column 2
R	the rank
eps	the tolerance for convergence; the default is 10^-5
ref	a vector of reference categories; the default is NULL and if NULL is used, the function will use the first category as the reference category for each row

Value

a list of outputs:

- Alpha: the final A matrix
- Gamma: the final G matrix
- Beta: the coefficient matrix for variables involved in reduced rank
- Dcoe: the coefficient matrix for the fixed variables
- Dsderr: the standard error matrix for the fixed variables
- Dpval: the p-value matrix for the fixed variables
- coemat: the overall coefficient matrix
- niter: the iteration number to get converged
- df: the degrees of freedom
- loglik: the final loglikelihood
- converge: three possible values with 0 means fail to converge, 1 means converges, and 2 means the maximum iteration is achieved

Examples

```
# generate the Markov chain
U=7
I1=I2=I3=rep(1,7)
I4=c(0,0,0,1,1,1,1)
I5=I6=I7=rep(0,7)
I=rbind(I1,I2,I3,I4,I5,I6,I7)
# prepare the data
data=cogdat
```

```
n=length(unique(data[,1]))
M=nrow(data)+n
Mc=0
z=matrix(0,n,9)
colnames(z)=colnames(data)[5:13]
T=matrix(0,M,3)
for(i in 1:n){
 subdat=data[which(data[,1]==i),,drop=FALSE]
 z[i,]=subdat[1,5:13]
 mc=nrow(subdat)
 T[(Mc+1):(Mc+mc+1),1]=i
 T[(Mc+1):(Mc+mc+1),2]=0:mc
 T[(Mc+1):(Mc+mc+1),3]=c(subdat[1,3],subdat[,4])
 Mc=Mc+mc+1
}
#z1=z[,c(1:3),drop=FALSE]
z2=z[,4,drop=FALSE]
# fit the model with rank 1
rrmultinom(I,z1=NULL,z2,T,1,eps=9,ref=c(1,1,1,4))
```

---

sdfun *sdfun*

Description

This function is used get the standard error matrix from bootstrap method It returns the matrices of standard error and p-value for the coefficient matrix

Usage

```
sdfun(I, z1 = NULL, z2 = NULL, T, R, eps = 1e-05, B, tpoint = NULL, ref)
```

Arguments

I	a U by U incidence matrix with elements; U is the number of states; I(i,j)=1 if state j can be accessed from state i in one step and 0 otherwise
z1	a n by p matrix with covariates involved in the dimension reduction(DR), n is the number of subjects, p is the number of covariates involved in DR
z2	a n by q matrix with study covariates (not in dimension reduction), q is the number of study covariates
T	a M by 3 state matrix, • the first column is a subject number between 1,..,n; • the second column is time; • the third column is the state occupied by subject in column 1 at time indicated in column 2
R	the rank

eps	the tolerance for convergence; the default is 10^-5
B	the bootstrap number
tpoint	a matrix has two columns with the participants' visit information about timeline
ref	a vector of reference categories

Value

a list of outputs:

- coe: the coefficient matrix of the original data
- sd: the standard error matrix
- pvalue: the p-value matrix

Examples

```
# generate the Markov chain
U=7
I1=I2=I3=rep(1,7)
I4=c(0,0,0,1,1,1,1)
I5=I6=I7=rep(0,7)
I=rbind(I1,I2,I3,I4,I5,I6,I7)
# prepare the data
data=cogdat
n=length(unique(data[,1]))
M=nrow(data)+n
Mc=0
z=matrix(0,n,9)
colnames(z)=colnames(data)[5:13]
T=matrix(0,M,3)
for(i in 1:n){
  subdat=data[which(data[,1]==i),,drop=FALSE]
  z[i,]=subdat[1,5:13]
  mc=nrow(subdat)
  T[(Mc+1):(Mc+mc+1),1]=i
  T[(Mc+1):(Mc+mc+1),2]=0:mc
  T[(Mc+1):(Mc+mc+1),3]=c(subdat[1,3],subdat[,4])
 Mc=Mc+mc+1
}
#z1=z[,c(1:3),drop=FALSE]
z2=z[,4,drop=FALSE]
# find the standard deviation matrix for the model with rank 1
sdfun(I,z1=NULL,z2,T,1,eps = 9,2,ref=c(1,1,1,4))
```

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