Package ‘EMMREML’

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Type Package

Title Fitting mixed models with known covariance structures.

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Depends Matrix

Description The main functions are emmreml, and emmremlMultiKernel. emmreml solves a mixed model with known covariance structure using the EMMA algorithm. emmremlMultiKernel is a wrapper for emmreml to handle multiple random components with known covariance structures. The function emmremlMultivariate solves a multivariate gaussian mixed model with known covariance structure using the ECM algorithm.

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Description

The main functions are emmreml and emmremlMultiKernel. emmreml solves a mixed model with known covariance structure using the EMMA algorithm in Kang et al. (2008). emmremlMultiKernel is a wrapper for emmreml to handle multiple random components with known covariance structures. The function emmremlMultivariate solves a multivariate gaussian mixed model with known covariance structure using the ECM algorithm in Zhou and Stephens (2012).

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References


Description

This function estimates the parameters of the model

\[ y = X\beta + Zu + e \]
where $y$ is the $n$ vector of response variable, $X$ is a $nxq$ known design matrix of fixed effects, $Z$ is a $nxl$ known design matrix of random effects, $\beta$ is $qx1$ vector of fixed effects coefficients and $u$ and $e$ are independent variables with $N_l(0, \sigma_u^2 K)$ and $N_n(0, \sigma_e^2 I_n)$ correspondingly. It also produces the BLUPs for the random effects.

**Usage**

```
emmreml(y, X, Z, K)
```

**Arguments**

- `y` $nx1$ numeric vector
- `X` $nxq$ matrix
- `Z` $nxl$ matrix
- `K` $lx1$ matrix of known relationships

**Value**

- `Vu` Estimate of $\sigma_u^2$
- `Ve` Estimate of $\sigma_e^2$
- `betahat` BLUEs for $\beta$
- `uhat` BLUPs for $u$

**Examples**

```r
n=300
M1<-matrix(rnorm(n*100), nrow=n)
K1<-cov(t(M1))
K1=K1/mean(diag(K1))

covY<-2*K1+1*diag(n)
Y<-10+crossprod(chol(covY), rnorm(n))

# training set
Trainset<-sample(1:300, 200)

funout<-emmreml(y=Y[Trainset], X=matrix(rep(1, n)[Trainset], ncol=1),
Z=diag(n)[Trainset,], K=K1)

cor(Y[-Trainset], funout$uhat[-Trainset])
```
**emmmremlMultiKernel**

*Function to fit Gaussian mixed model with multiple mixed effects with known covariances.*

**Description**

This function is a wrapper for the emmreml to fit Gaussian mixed model with multiple mixed effects with known covariances. The model fitted is $y = X\beta + Z_1u_1 + Z_2u_2 + ... + Z_ku_k + e$ where $y$ is the $n$ vector of response variable, $X$ is a $nxq$ known design matrix of fixed effects, $Z_j$ is a $nxl_j$ known design matrix of random effects for $j = 1, 2, ..., k$, $\beta$ is $nx1$ vector of fixed effects coefficients and $U = (\tilde{u}_1, \tilde{u}_2, ..., \tilde{u}_k)^t$ and $e$ are independent variables with $N_L(0, \text{blockdiag}(\sigma^2_{u_1}K_1, \sigma^2_{u_2}K_2, ..., \sigma^2_{u_k}K_k))$ and $N_n(0, \sigma^2_eI_n)$ correspondingly. It also produces the BLUPs for the $L = l_1 + l_2 + ... + l_k$ dimensional random effect $U$. The variance parameters for random effects are estimated as $(\hat{w}_1, \hat{w}_2, ..., \hat{w}_k) \ast \sigma^2_u$ where $w = (w_1, w_2, ..., w_k)$ are the kernel weights.

**Usage**

```r
data <- emmremlMultiKernel(y, X, Zlist, Klist)
```

**Arguments**

- **y**: $nx1$ numeric vector
- **X**: $nxq$ matrix
- **Zlist**: list of random effects design matrices of dimensions $nxl_1, ..., nxl_k$
- **Klist**: list of known relationship matrices of dimensions $l_1xl_1, ..., l_kxl_k$

**Value**

- **Vu**: Estimate of $\sigma^2_u$
- **Ve**: Estimate of $\sigma^2_e$
- **betahat**: BLUEs for $\beta$
- **uhat**: BLUPs for $u$
- **weights**: Estimates of kernel weights

**Examples**

```r
###example
data from gaussian process with three
#(total four, including residuals) independent
#sources of variation

n=100
M1<-matrix(rnorm(n*10), nrow=n)
```
# Relationship matrices
k1 <- cov(t(M1))
k2 <- cov(t(M2))
k3 <- cov(t(M3))
k1 <- k1/mean(diag(k1))
k2 <- k2/mean(diag(k2))
k3 <- k3/mean(diag(k3))

# Generate data
covY <- 2*(.2*k1 + .7*k2 + .1*k3) + diag(n)
Y <- 10 + crossprod(chol(covY), rnorm(n))

# Training set
Trainsamp <- sample(1:100, 80)

funout <- emmremlMultikernel(y = Y[Trainsamp], X = matrix(rep(1, n)[Trainsamp], ncol = 1),
Zlist = list(diag(n)[Trainsamp], diag(n)[Trainsamp], diag(n)[Trainsamp], diag(n)[Trainsamp]),
Klist = list(K1, K2, K3))

weights
funout$weights

# Correlation of predictions with true values in test set
uhatmat <- matrix(funout$uhat, ncol = 3)
uhatvec <- rowSums(uhatmat)

cor(Y[-Trainsamp], uhatvec[-Trainsamp])

---

**emmremlMultivariate**  
*Function to fit multivariate Gaussian mixed model with known covariance structure.*

**Description**

This function estimates the parameters of the model

\[ Y = BX + GZ + E \]

where \( Y \) is the \( d \times n \) matrix of response variable, \( X \) is a \( q \times n \) known design matrix of fixed effects, \( Z \) is a \( l \times n \) known design matrix of random effects, \( B \) is \( d \times q \) matrix of fixed effects coefficients and \( G \) and \( G \) are independent matrix variate variables with \( N_{d \times l}(0, V_G, K) \) and \( N_{d \times n}(0, V_E, I_n) \) correspondingly. It also produces the BLUPs for the random effects \( G \).

**Usage**

`emmremlMultivariate(Y, X, Z, K, tolpar = 1e-04, tolparinv = 1e-04)`
Arguments

\[ Y \] \( dxn \) matrix of response variable
\[ X \] \( qxn \) known design matrix of fixed effects
\[ Z \] \( lxn \) known design matrix of random effects
\[ K \] \( lxl \) matrix of known relationships
\[ \text{tolpar} \] tolerance parameter for convergence
\[ \text{tolparinv} \] tolerance parameter for matrix inverse

Value

\[ \text{vg} \] Estimate of \( V_G \)
\[ \text{ve} \] Estimate of \( V_E \)
\[ \text{bhat} \] BLUES for \( B \)
\[ \text{gpred} \] BLUPs for \( G \)

Examples

```r
m<-20
n<-15
m<-40

M<-matrix(rbinom(m*1,2,2),nrow=1)
rownames(M)<-paste("1",1:nrow(M))
beta1<-rnorm(5)*exp(rbinom(m,5,2))
beta2<-rnorm(5)*exp(rbinom(m,5,1))
beta3<-rnorm(5)*exp(rbinom(m,5,1))+beta2
g1<-M%*%beta1
g2<-M%*%beta2
g3<-M%*%beta3
e1<-sd(g1)*rnorm(1)
e2<-(-e1*2*sd(g2)/sd(g1)+.25*sd(g2)/sd(g1)*rnorm(1))
e3<-1*(e1*.25*sd(g2)/sd(g1)+.25*sd(g2)/sd(g1)*rnorm(1))
y1<-10+g1+e1
y2<-5+g2+e2
y3<-5+g3+e3
Y<-cbind(t(y1),t(y2),t(y3))

colnames(Y)<-rownames(M)
cov(t(Y))
Y[1:3,1:5]

K<-cov(t(M))
K<-K/mean(diag(K))
rownames(K)<-colnames(K)<-rownames(M)
X<-matrix(1,nrow=1,ncol=1)
colnames(X)<-rownames(M)
```
Z <- diag(1)
rownames(Z) <- colnames(Z) <- rownames(M)
SampleTrain <- sample(rownames(Z), n)
Ztrain <- Z[rownames(Z) %in% SampleTrain,]
Ztest <- Z[!(rownames(Z) %in% SampleTrain),]

cor(cbind(Ztest$X[1,], Ztest$X[outfunc$Gpred2[1,]],
Ztest$X[2,], Ztest$X[outfunc$Gpred2[2,]],
Ztest$X[3,], Ztest$X[outfunc$Gpred2[3,]]))

cor(Ztest$X[1,], Ztest$X[outfunc$Gpred2[1,]])
cor(Ztest$X[2,], Ztest$X[outfunc$Gpred2[2,]])
cor(Ztest$X[3,], Ztest$X[outfunc$Gpred2[3,]])
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