

# Package ‘fence’

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**Type** Package

**Title** Using Fence Methods for Model Selection

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**Description** This method is a new class of model selection strategies, for mixed model selection, which includes linear and generalized linear mixed models. The idea involves a procedure to isolate a subgroup of what are known as correct models (of which the optimal model is a member). This is accomplished by constructing a statistical fence, or barrier, to carefully eliminate incorrect models. Once the fence is constructed, the optimal model is selected from among those within the fence according to a criterion which can be made flexible.

References:

1. Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. *The Annals of Statistics*, 36(4): 1669-1692.  
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<[http://publications.gc.ca/collections/collection\\_2010/statcan/12-001-X/12-001-x2010001-eng.pdf](http://publications.gc.ca/collections/collection_2010/statcan/12-001-X/12-001-x2010001-eng.pdf)>.
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<[http://www.intlpress.com/site/pub/files/\\_fulltext/journals/sii/2011/0004/0003/SII-2011-0004-0003-a014.pdf](http://www.intlpress.com/site/pub/files/_fulltext/journals/sii/2011/0004/0003/SII-2011-0004-0003-a014.pdf)>.
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<[DOI:10.1080/00949655.2012.721885](https://doi.org/10.1080/00949655.2012.721885)> <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3891925/>>.
7. Jiang, J. (2014), The fence methods, in *Advances in Statistics*, Hindawi Publishing Corp., Cairo.  
<[DOI:10.1155/2014/830821](https://doi.org/10.1155/2014/830821)>.
8. Jiming Jiang and Thuan Nguyen (2015), *The Fence Methods*, World Scientific, Singapore.  
<<https://www.abebooks.com/9789814596060/Fence-Methods-Jiming-Jiang-981459606X/plp>>.

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adaptivefence	<i>Adaptive Fence model selection</i>
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**Description**

Adaptive Fence model selection

**Usage**

```
adaptivefence(mf, f, ms, d, lf, pf, bs, grid = 101, bandwidth)
```

**Arguments**

mf	function for fitting the model
f	formula of full model
ms	list of formula of candidates models
d	data
lf	measure lack of fit (to minimize)
pf	model selection criteria, e.g., model dimension
bs	bootstrap samples
grid	grid for c
bandwidth	bandwidth for kernel smooth function

**Value**

models	list all model candidates in the model space
B	list the number of bootstrap samples that have been used
lack_of_fit_matrix	list a matrix of Qs for all model candidates (in columns). Each row is for each bootstrap sample
Qd_matrix	list a matrix of $QM - QM.tilde$ for all model candidates. Each row is for each bootstrap sample
bandwidth	list the value of bandwidth
model_mat	list a matrix of selected models at each c values in grid (in columns). Each row is for each bootstrap sample
freq_mat	list a matrix of coverage probabilities (frequency/smooth_frequency) of each selected models for a given c value (index)
c	list the adaptive choice of c value from which the parsimonious model is selected
sel_model	list the selected (parsimonious) model given the adaptive c value

**Author(s)**

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

## References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

## Examples

```
## Not run:
require(fence)

#### Example 1 #####
data(iris)
full = Sepal.Length ~ Sepal.Width + Petal.Length + Petal.Width + (1|Species)
test_af = fence.lmer(full, iris)
plot(test_af)
test_af$sel_model

#### Example 2 #####
r =1234; set.seed(r)
p=8; n=150; rho = 0.6
id = rep(1:50,each=3)
R = diag(p)
for(i in 1:p){
  for(j in 1:p){
    R[i,j] = rho^(abs(i-j))
  }
}
R = 1*R
x=mvnrnorm(n, rep(0, p), R) # all x's are time-varying dependence #
colnames(x)=paste('x',1:p, sep='')
tbetas = c(0,0.5,1,0,0.5,1,0,0.5) # non-zero beta 2,3,5,6,8
epsilon = rnorm(150)
y = x%*%tbetas + epsilon
colnames(y) = 'y'
data = data.frame(cbind(x,y,id))
full = y ~ x1+x2+x3+x4+x5+x6+x7+x8+(1|id)
#X = paste('x',1:p, sep='', collapse='+')
#full = as.formula(paste('y~',X,'+(1|id)', sep="")) #same as previous one
fence_obj = fence.lmer(full,data) # it takes 3-5 min #
plot(fence_obj)
fence_obj$sel_model

## End(Not run)
```

---

adaptivefence.fh      *Adaptive Fence model selection (Small Area Estimation)*

---

## Description

Adaptive Fence model selection (Small Area Estimation)

## Usage

```
adaptivefence.fh(mf, f, ms, d, lf, pf, bs, grid = 101, bandwidth, method)
```

## Arguments

mf	Call function, for example: default calls: function(m, b) eblupFH(formula = m, vardir = D, data = b, method = "FH")
f	Full Model
ms	find candidate model, findsubmodel.fh(full)
d	Dimension number
lf	Measures lack of fit using function(res) -res\$fit\$goodness[1]
pf	Dimensions of model
bs	Bootstrap
grid	grid for c
bandwidth	bandwidth for kernel smooth function
method	Method to be used. Fay-Herriot method is the default.

## Details

In Jiang et. al (2008), the adaptive  $c$  value is chosen from the highest peak in the  $p^*$  vs.  $c$  plot. In Jiang et. al (2009), 95% CI is taken into account while choosing such an adaptive choice of  $c$ . In Thuan Nguyen et. al (2014), the adaptive  $c$  value is chosen from the first peak. This approach works better in the moderate sample size or weak signal situations. Empirically, the first peak becomes highest peak when sample size increases or signals become stronger

## Value

models	list all model candidates in the model space
B	list the number of bootstrap samples that have been used
lack_of_fit_matrix	list a matrix of $Q_s$ for all model candidates (in columns). Each row is for each bootstrap sample
Qd_matrix	list a matrix of $QM - QM.tilde$ for all model candidates. Each row is for each bootstrap sample
bandwidth	list the value of bandwidth

model_mat	list a matrix of selected models at each c values in grid (in columns). Each row is for each bootstrap sample
freq_mat	list a matrix of coverage probabilities (frequency/smooth_frequency) of each selected models for a given c value (index)
c	list the adaptive choice of c value from which the parsimonious model is selected
sel_model	list the selected (parsimonious) model given the adaptive c value

### Note

- The current Fence package focuses on variable selection. However, Fence methods can be used to select other parameters of interest, e.g., tuning parameter, variance-covariance structure, etc.
- The number of bootstrap samples is suggested to be increased, e.g.,  $B=1000$  when the sample size is small, or signals are weak

### Author(s)

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

### References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

### Examples

```
## Not run:
require(fence)
### example 1 ####
data("kidney")
data = kidney[-which.max(kidney$x),]      # Delete a suspicious data point #
data$x2 = data$x^2
data$x3 = data$x^3
data$x4 = data$x^4
data$D = data$sqrt.D.^2
plot(data$y ~ data$x)
full = y~x+x2+x3+x4
testfh = fence.sae(full, data, B=1000, fence="adaptive", method="F-H", D = D)
testfh$sel_model
testfh$c

## End(Not run)
```

---

fence.lmer                      *Fence model selection (Linear Mixed Model)*

---

## Description

Fence model selection (Linear Mixed Model)

## Usage

```
fence.lmer(full, data, B = 100, grid = 101, fence = c("adaptive",
  "nonadaptive"), cn = NA, REML = TRUE, bandwidth = NA,
  cpus = parallel::detectCores())
```

## Arguments

full	formula of full model
data	data
B	number of bootstrap samples, parametric bootstrap is used
grid	grid for c
fence	a procedure of the fence method to be used. It's suggested to choose nonadaptive procedure if c is known; otherwise nonadaptive must be chosen
cn	cn value for nonadaptive
REML	Restricted Maximum Likelihood approach
bandwidth	bandwidth for kernel smooth function
cpus	Number of parallel computers

## Details

In Jiang et. al (2008), the adaptive c value is chosen from the highest peak in the  $p^*$  vs. c plot. In Jiang et. al (2009), 95% CI is taken into account while choosing such an adaptive choice of c. In Thuan Nguyen et. al (2014), the adaptive c value is chosen from the first peak. This approach works better in the moderate sample size or weak signal situations. Empirically, the first peak becomes highest peak when sample size increases or signals become stronger

## Value

models	list all model candidates in the model space
B	list the number of bootstrap samples that have been used
lack_of_fit_matrix	list a matrix of Qs for all model candidates (in columns). Each row is for each bootstrap sample
Qd_matrix	list a matrix of $QM - QM.tilde$ for all model candidates. Each row is for each bootstrap sample
bandwidth	list the value of bandwidth

model\_mat      list a matrix of selected models at each c values in grid (in columns). Each row is for each bootstrap sample

freq\_mat      list a matrix of coverage probabilities (frequency/smooth\_frequency) of each selected models for a given c value (index)

c                list the adaptive choice of c value from which the parsimonious model is selected

sel\_model      list the selected (parsimonious) model given the adaptive c value

@note The current Fence package focuses on variable selection. However, Fence methods can be used to select other parameters of interest, e.g., tuning parameter, variance-covariance structure, etc.

### Author(s)

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

### References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

### Examples

```
require(fence)
library(snow)

#### Example 1 #####
data(iris)
full = Sepal.Length ~ Sepal.Width + Petal.Length + Petal.Width + (1|Species)
# Takes greater than 5 seconds to run
# test_af = fence.lmer(full, iris)
# test_af$c
# test_naf = fence.lmer(full, iris, fence = "nonadaptive", cn = 12)
# plot(test_af)
# test_af$sel_model
# test_naf$sel_model
```

---

fence.NF

*Fence model selection (Nonparametric Model)*

---

### Description

Fence model selection (Nonparametric Model)

**Usage**

```
fence.NF(full, data, spline, ps = 1:3, qs = NA, B = 100, grid = 101,
         bandwidth = NA, lambda)
```

**Arguments**

full	formula of full model
data	data
spline	variable needed for spline terms
ps	order of power
qs	number of knots
B	number of bootstrap sample, parametric for lmer
grid	grid for c
bandwidth	bandwidth for kernel smooth function
lambda	A grid of lambda values

**Value**

models	list all model candidates with p polynomial degrees and q knots in the model space
Qd_matrix	list a matrix of $QM - QM.tilde$ for all model candidates. Each row is for each bootstrap sample
bandwidth	list the value of bandwidth
model_mat	list a matrix of selected models at each c values in grid (in columns). Each row is for each bootstrap sample
freq_mat	list a matrix of coverage probabilities (frequency/smooth_frequency) of each selected models for a given c value (index)
c	list the adaptive choice of c value from which the parsimonious model is selected
lambda	penalty (or smoothing) parameter estimate given selected p and q
sel_model	list the selected (parsimonious) model given the adaptive c value
beta.est.u	A list of coefficient estimates given a lambda value
f.x.hat	A vector of fitted values obtained from a given lambda value and beta.est.u

@note The current Fence method in Nonparametric model focuses on one spline variable. This method can be extended to a general case with more than one spline variables, and includes non-spline variables.

**Author(s)**

Jiming Jiang Jianyang Zhao J. Sunil Rao Bao-Qui Tran Thuan Nguyen

## References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. *The Annals of Statistics*, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. *Statistics and Probability Letters*, 79, 625-629
- Jiang J., Nguyen T., Rao J.S. (2010), Fence Method for Nonparametric Small Area Estimation. *Survey Methodology*, 36, 1, 3-11

## Examples

```
## Not run:
require(fence)
n = 100
set.seed(1234)
x=runif(n,0,3)
y = 1-x+x^2- 2*(x-1)^2*(x>1) + 2*(x-2)^2*(x>2) + rnorm(n,sd=.2)
lambda=exp((c(1:60)-30)/3)
data=data.frame(cbind(x,y))
test_NF = fence.NF(full=y~x, data=data, spline='x', ps=c(1:3), qs=c(2,5), B=1000, lambda=lambda)
plot(test_NF)
summary <- summary(test_NF)
model_sel <- summary[[1]]
model_sel
lambda_sel <- summary[[2]]
lambda_sel

## End(Not run)
```

---

fence.sae

*Fence model selection (Small Area Estimation)*

---

## Description

Fence model selection (Small Area Estimation)

## Usage

```
fence.sae(full, data, B = 100, grid = 101, fence = c("adaptive",
  "nonadaptive"), cn = NA, method = c("F-H", "NER"), D = NA,
  REML = FALSE, bandwidth = NA, cpus = parallel::detectCores())
```

## Arguments

full	formular of full model
data	data
B	number of bootstrap sample, parametric for lmer
grid	grid for c

fence	fence method to be used, e.g., adaptive, or nonadaptive. It's suggested to choose nonadaptive procedure if $c$ is known; otherwise nonadaptive must be chosen
cn	cn for nonadaptive
method	Select method to use
D	vector containing the D sampling variances of direct estimators for each domain. The values must be sorted as the variables in formula. Only used in FH model
REML	Restricted Maximum Likelihood approach
bandwidth	bandwidth for kernel smooth function
cpus	Number of parallel computers

### Details

In Jiang et. al (2008), the adaptive  $c$  value is chosen from the highest peak in the  $p^*$  vs.  $c$  plot. In Jiang et. al (2009), 95% CI is taken into account while choosing such an adaptive choice of  $c$ . In Thuan Nguyen et. al (2014), the adaptive  $c$  value is chosen from the first peak. This approach works better in the moderate sample size or weak signal situations. Empirically, the first peak becomes highest peak when sample size increases or signals become stronger

### Value

models	list all model candidates in the model space
B	list the number of bootstrap samples that have been used
lack_of_fit_matrix	list a matrix of $Q_s$ for all model candidates (in columns). Each row is for each bootstrap sample
Qd_matrix	list a matrix of $QM - \tilde{QM}$ for all model candidates. Each row is for each bootstrap sample
bandwidth	list the value of bandwidth
model_mat	list a matrix of selected models at each $c$ values in grid (in columns). Each row is for each bootstrap sample
freq_mat	list a matrix of coverage probabilities (frequency/smooth_frequency) of each selected models for a given $c$ value (index)
c	list the adaptive choice of $c$ value from which the parsimonious model is selected
sel_model	list the selected (parsimonious) model given the adaptive $c$ value

### Note

- The current Fence package focuses on variable selection. However, Fence methods can be used to select other parameters of interest, e.g., tuning parameter, variance-covariance structure, etc.
- The number of bootstrap samples is suggested to be increased, e.g.,  $B=1000$  when the sample size is small, or signals are weak

### Author(s)

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

## References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

## Examples

```
require(fence)
library(snow)
### example 1 ####
data("kidney")
data = kidney[-which.max(kidney$x),]      # Delete a suspicious data point #
data$x2 = data$x^2
data$x3 = data$x^3
data$x4 = data$x^4
data$D = data$sqrt.D.^2
plot(data$y ~ data$x)
full = y~x+x2+x3+x4
# Takes more than 5 seconds to run
# testfh = fence.sae(full, data, B=100, fence="adaptive", method="F-H", D = D)
# testfh$sel_model
# testfh$c
```

---

IF.lm

*Invisible Fence model selection (Linear Model)*

---

## Description

Invisible Fence model selection (Linear Model)

## Usage

```
IF.lm(full, data, B = 100, cpus = 2, lftype = c("abscoef", "pvalue"))
```

## Arguments

full	formula of full model
data	data
B	number of bootstrap sample, parametric for lm
cpus	number of parallel computers
lftype	subtractive measure type, e.g., absolute value of coefficients, p-value, t-value, etc.

## Details

This method (Jiang et. al, 2011) is motivated by computational expensive in complex and high dimensional problem. The idea of the method—there is the best model in each dimension (in model space). The bootstrapping determines the coverage probability of the selected model in each dimensions. The parsimonious model is the selected model with the highest coverage probability (except the one for the full model, always probability of 1.)

## Value

full	list the full model
B	list the number of bootstrap samples that have been used
freq	list the coverage probabilities of the selected model for each dimension
size	list the number of variables in the parsimonious model
term	list variables included in the full model
model	list the variables selected in-the-order in the parsimonious model

@note The current Invisible Fence focuses on variable selection. The current routine is applicable to the case in which the subtractive measure is the absolute value of the coefficients, p-value, t-value. However, the method can be extended to other subtractive measures. See Jiang et. al (2011) for more details.

## Author(s)

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

## References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiming Jiang, Thuan Nguyen and J. Sunil Rao (2011), Invisible fence methods and the identification of differentially expressed gene sets. Statistics and Its Interface, Volume 4, 403-415.

## Examples

```
library(fence)
library(MASS)
library(snow)
r =1234; set.seed(r)
p=10; n=300; rho = 0.6
R = diag(p)
for(i in 1:p){
  for(j in 1:p){
    R[i,j] = rho^(abs(i-j))
  }
}
R = 1*R
x=mvrnorm(n, rep(0, p), R)
colnames(x)=paste('x',1:p, sep='')
X = cbind(rep(1,n),x)
```

```

tbetas = c(1,1,1,0,1,1,0,1,0,0,0) # non-zero beta 1,2,4,5,7
epsilon = rnorm(n)
y = as.matrix(X)%*%tbetas + epsilon
colnames(y) = 'y'
data = data.frame(cbind(X,y))
full = y ~ x1+x2+x3+x4+x5+x6+x7+x8+x9+x10
# Takes greater than 5 seconds (~17 seconds) to run
# obj1 = IF.lm(full = full, data = data, B = 100, lftype = "abscoef")
# sort((names(obj1$model$coef)[-1]))
# obj2 = IF.lm(full = full, data = data, B = 100, lftype = "pvalue")
# sort(setdiff(names(data[c(-1,-12)]), names(obj2$model$coef)))

```

---

IF.lmer

---

*Invisible Fence model selection (Linear Mixed Model)*


---

### Description

Invisible Fence model selection (Linear Mixed Model)

### Usage

```

IF.lmer(full, data, B = 100, REML = TRUE, method = c("marginal",
"conditional"), cpus = parallel::detectCores(), lftype = c("abscoef",
"tvalue"))

```

### Arguments

full	formula of full model
data	data
B	number of bootstrap sample, parametric for lmer
REML	Restricted maximum likelihood estimation
method	choose either marginal (e.g., GEE) or conditional model
cpus	Number of parallel computers
lftype	subtractive measure type, e.g., absolute value of coefficients, p-value, t-value, etc.

### Details

This method (Jiang et. al, 2011) is motivated by computational expensive in complex and high dimensional problem. The idea of the method—there is the best model in each dimension (in model space). The bootstrapping determines the coverage probability of the selected model in each dimensions. The parsimonious model is the selected model with the highest coverage probably (except the one for the full model, always probability of 1.)

**Value**

full	list the full model
B	list the number of bootstrap samples that have been used
freq	list the coverage probabilities of the selected model for each dimension
size	list the number of variables in the parsimonious model
term	list variables included in the full model
model	list the variables selected in-the-order in the parsimonious model

@note The current Invisible Fence focuses on variable selection. The current routine is applicable to the case in which the subtractive measure is the absolute value of the coefficients, p-value, t-value. However, the method can be extended to other subtractive measures. See Jiang et. al (2011) for more details.

**Author(s)**

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

**References**

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiming Jiang, Thuan Nguyen and J. Sunil Rao (2011), Invisible fence methods and the identification of differentially expressed gene sets. Statistics and Its Interface, Volume 4, 403-415.

**Examples**

```
require(fence)
library(snow)
library(MASS)
data("X.lmer")
data = data.frame(X.lmer)
# non-zero beta I.col.2, I.col.3a, I.col.3b, V5, V7, V8, V9
beta = matrix(c(0, 1, 1, 1, 1, 0, 0.1, 0.05, 0.25, 0), ncol = 1)
set.seed(1234)
alpha = rep(rnorm(100), each = 3)
mu = alpha + as.matrix(data[, -1]) %*% beta
data$id = as.factor(data$id)
data$y = mu + rnorm(300)
raw = "y ~ (1|id)+I.col.2+I.col.3a+I.col.3b"
for (i in 5:10) {
  raw = paste0(raw, "+V", i)
}
full = as.formula(raw)
# The following output takes more than 5 seconds (~70 seconds) to run.

# obj1.lmer = IF.lmer(full = full, data = data, B = 100, method="conditional", lftype = "abscoef")
# sort(obj1.lmer$model)

# obj2.lmer = IF.lmer(full = full, data = data, B = 100, method="conditional", lftype = "tvalue")
```

```
# sort(obj2.lmer$model)

# Similarly, the following scenarios can be run

# obj2.lmer = IF.lmer(full = full, data = data, B = 100, method="conditional", lftype = "tvalue")
# sort(obj2.lmer$model)
# obj1.lm = IF.lmer(full = full, data = data, B = 100, method="marginal", lftype = "abscoef")
# sort(names(obj1.lm$model$coefficients[-1]))
# obj2.lm = IF.lmer(full = full, data = data, B = 100, method="marginal", lftype = "tvalue")
# sort(names(obj2.lm$model$coefficients[-1]))
```

---

invisiblefence

*Invisible Fence model selection*


---

## Description

Invisible Fence model selection

## Usage

```
invisiblefence(mf, f, d, lf, bs)
```

## Arguments

mf	Call function, for example: default calls: function(m, b) eblupFH(formula = m, vardir = D, data = b, method = "FH")
f	Full model
d	Dimension number
lf	Measures lack of fit using function(res) -res\$fit\$goodness[1]
bs	Bootstrap

## Details

This method (Jiang et. al, 2011) is motivated by computational expensive in complex and high dimensional problem. The idea of the method—there is the best model in each dimension (in model space). The bootstrapping determines the coverage probability of the selected model in each dimensions. The parsimonious model is the selected model with the highest coverage probability (except the one for the full model, always probability of 1.)

## Value

full	list the full model
B	list the number of bootstrap samples that have been used
freq	list the coverage probabilities of the selected model for each dimension
size	list the number of variables in the parsimonious model

term            list variables included in the full model  
 model          list the variables selected in-the-order in the parsimonious model

@note The current Invisible Fence focuses on variable selection. The current routine is applicable to the case in which the subtractive measure is the absolute value of the coefficients, p-value, t-value. However, the method can be extended to other subtractive measures. See Jiang et. al (2011) for more details.

### Author(s)

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

### References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiming Jiang, Thuan Nguyen and J. Sunil Rao (2011), Invisible fence methods and the identification of differentially expressed gene sets. Statistics and Its Interface, Volume 4, 403-415.

### Examples

```
## Not run:
data("X.lmer")
data = data.frame(X.lmer)
beta = matrix(c(0, 1, 1, 1, 1, 0, 0.1, 0.05, 0.25, 0), ncol = 1)
set.seed(1234)
alpha = rep(rnorm(100), each = 3)
mu = alpha + as.matrix(data[,-1]) %*% beta
data$id = as.factor(data$id)
data$y = mu + rnorm(300)
raw = "y ~ (1|id)+I.col.2+I.col.3a+I.col.3b"
for (i in 5:10) {
  raw = paste0(raw, "+V", i)
}
full = as.formula(raw)
obj1.lmer = IF.lmer(full = full, data = data, B = 100, method="conditional", lftype = "abscoef")
obj1.lmer$model$coefficients
obj2.lmer = IF.lmer(full = full, data = data, B = 100, method="conditional", lftype = "tvalue")
obj2.lmer$model$coefficients
obj1.lm = IF.lmer(full = full, data = data, B = 100, method="marginal", lftype = "abscoef")
obj1.lm$model$coefficients
obj2.lm = IF.lmer(full = full, data = data, B = 100, method="marginal", lftype = "tvalue")
obj2.lm$model$coefficients

## End(Not run)
```

---

kidney	<i>kidney</i>
--------	---------------

---

**Description**

Data used for kidney example

**Usage**

kidney

**Format**

A data frame with 4 variables

---

nonadaptivefence	<i>Nonadaptive Fence model selection</i>
------------------	--

---

**Description**

Nonadaptive Fence model selection

**Usage**

```
nonadaptivefence(mf, f, ms, d, lf, pf, cn)
```

**Arguments**

mf	function for fitting the model
f	formula of full model
ms	list of formula of candidates models
d	data
lf	measure lack of fit (to minimize)
pf	model selection criteria, e.g., model dimension
cn	given a specific c value

**Value**

models	list all model candidates in the model space
lack_of_fit	list a vector of Qs for all model candidates
formula	list the model of the selected parsimonious model
sel_model	list the selected (parsimonious) model given the adaptive c value

**Author(s)**

Jiming Jiang Jianyang Zhao J. Sunil Rao Thuan Nguyen

**References**

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

**Examples**

```
## Not run:
require(fence)

#### Example 1 #####
data(iris)
full = Sepal.Length ~ Sepal.Width + Petal.Length + Petal.Width + (1|Species)
test_naf = fence.lmer(full, iris, fence = "nonadaptive", cn = 12)
test_naf$sel_model

## End(Not run)
```

---

plot.AF

*Plot Adaptive Fence model selection*

---

**Description**

Plot Adaptive Fence model selection

**Usage**

```
## S3 method for class 'AF'
plot(x = res, ...)
```

**Arguments**

x                    Object to be plotted  
...                   Additional arguments. CNot currently used.

---

plot.NF	<i>Plot Nonparametric Fence model selection</i>
---------	---

---

**Description**

Plot Nonparametric Fence model selection

**Usage**

```
## S3 method for class 'NF'
plot(x = res, ...)
```

**Arguments**

x	Object to be plotted
...	Additional arguments. CNot currently used.

---

RF	<i>Adaptive Fence model selection (Restricted Fence)</i>
----	--

---

**Description**

Adaptive Fence model selection (Restricted Fence)

**Usage**

```
RF(full, data, groups, B = 100, grid = 101, bandwidth = NA,
    plot = FALSE, method = c("marginal", "conditional"), id = "id",
    cpus = parallel::detectCores())
```

**Arguments**

full	formula of full model
data	data
groups	A list of formulas of (full) model in each bins (groups) of variables
B	number of bootstrap sample, parametric for lmer
grid	grid for c
bandwidth	bandwidth for kernel smooth function
plot	Plot object
method	either marginal (GEE) or conditional approach is selected
id	Subject or cluster id variable
cpus	Number of parallel computers

## Details

In Jiang et. al (2008), the adaptive  $c$  value is chosen from the highest peak in the  $p^*$  vs.  $c$  plot. In Jiang et. al (2009), 95% CI is taken into account while choosing such an adaptive choice of  $c$ . In Thuan Nguyen et. al (2014), the adaptive  $c$  value is chosen from the first peak. This approach works better in the moderate sample size or weak signal situations. Empirically, the first peak becomes highest peak when sample size increases or signals become stronger

## Value

<code>models</code>	list all model candidates in the model space
<code>B</code>	list the number of bootstrap samples that have been used
<code>lack_of_fit_matrix</code>	list a matrix of $Q_s$ for all model candidates (in columns). Each row is for each bootstrap sample
<code>Qd_matrix</code>	list a matrix of $QM - QM.tilde$ for all model candidates. Each row is for each bootstrap sample
<code>bandwidth</code>	list the value of bandwidth
<code>model_mat</code>	list a matrix of selected models at each $c$ values in grid (in columns). Each row is for each bootstrap sample
<code>freq_mat</code>	list a matrix of coverage probabilities (frequency/smooth_frequency) of each selected models for a given $c$ value (index)
<code>c</code>	list the adaptive choice of $c$ value from which the parsimonious model is selected
<code>sel_model</code>	list the selected (parsimonious) model given the adaptive $c$ value

## Note

`bandwidth = (cs[2] - cs[1]) * 3`. So it's chosen as 3 times grid between two  $c$  values.

## References

- Jiang J., Rao J.S., Gu Z., Nguyen T. (2008), Fence Methods for Mixed Model Selection. The Annals of Statistics, 36(4): 1669-1692
- Jiang J., Nguyen T., Rao J.S. (2009), A Simplified Adaptive Fence Procedure. Statistics and Probability Letters, 79, 625-629
- Thuan Nguyen, Jiming Jiang (2012), Restricted fence method for covariate selection in longitudinal data analysis. Biostatistics, 13(2), 303-314
- Thuan Nguyen, Jie Peng, Jiming Jiang (2014), Fence Methods for Backcross Experiments. Statistical Computation and Simulation, 84(3), 644-662

## Examples

```
## Not run:
r =1234; set.seed(r)
n = 100; p=15; rho = 0.6
beta = c(1,1,1,0,1,1,0,1,0,0,1,0,0,0,0) # non-zero beta 1,2,3,V6,V7,V9,V12
id = rep(1:n,each=3)
```

```

V.1 = rep(1,n*3)
I.1 = rep(c(1,-1),each=150)
I.2a = rep(c(0,1,-1),n)
I.2b = rep(c(0,-1,1),n)
x = matrix(rnorm(n*3*11), nrow=n*3, ncol=11)
x = cbind(id,V.1,I.1,I.2a,I.2b,x)
R = diag(3)
for(i in 1:3){
  for(j in 1:3){
    R[i,j] = rho^(abs(i-j))
  }
}
e=as.vector(t(mvnrnorm(n, rep(0, 3), R)))
y = as.vector(x[,-1]%*%beta) + e
data = data.frame(x,y)
raw = "y ~ V.1 + I.1 + I.2a +I.2b"
for (i in 6:16) { raw = paste0(raw, "+V", i)}; full = as.formula(raw)
bin1="y ~ V.1 + I.1 + I.2a +I.2b"
for (i in 6:8) { bin1 = paste0(bin1, "+V", i)}; bin1 = as.formula(bin1)
bin2="y ~ V9"
for (i in 10:16){ bin2 = paste0(bin2, "+V", i)}; bin2 = as.formula(bin2)
# May take longer than 30 min since there are two stages in this RF procedure
obj1.RF = RF(full = full, data = data, groups = list(bin1,bin2), method="conditional")
obj1.RF$sel_model
obj2.RF = RF(full = full, data = data, groups = list(bin1,bin2), B=100, method="marginal")
obj2.RF$sel_model

## End(Not run)

```

---

summary.AF

*Summary Adaptive Fence model selection*


---

## Description

Summary Adaptive Fence model selection

## Usage

```

## S3 method for class 'AF'
summary(object = res, ...)

```

## Arguments

object	Object to be summarized
...	addition arguments. Not currently used

---

summary.NF	<i>Summary Nonparametric Fence model selection</i>
------------	--

---

**Description**

Summary Nonparametric Fence model selection

**Usage**

```
## S3 method for class 'NF'  
summary(object = res, ...)
```

**Arguments**

object	Object to be summarized
...	addition arguments. Not currently used

---

X.lmer	<i>X.lmer</i>
--------	---------------

---

**Description**

Data used in the example for X.lmer

**Usage**

```
data(X.lmer)
```

**Format**

A data frame with 10 variables:

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