

# Package ‘ALTopt’

October 12, 2022

**Title** Optimal Experimental Designs for Accelerated Life Testing

**Version** 0.1.2

**Description** Creates the optimal (D, U and I) designs for the accelerated life testing with right censoring or interval censoring. It uses generalized linear model (GLM) approach to derive the asymptotic variance-covariance matrix of regression coefficients. The failure time distribution is assumed to follow Weibull distribution with a known shape parameter and log-linear link functions are used to model the relationship between failure time parameters and stress variables. The acceleration model may have multiple stress factors, although most ALTs involve only two or less stress factors. ALTopt package also provides several plotting functions including contour plot, Fraction of Use Space (FUS) plot and Variance Dispersion graphs of Use Space (VDUS) plot. For more details, see Seo and Pan (2015) <[doi:10.32614/RJ-2015-029](https://doi.org/10.32614/RJ-2015-029)>.

**Depends** R (>= 3.0.0)

**License** GPL-3

**LazyData** true

**Imports** cubature (>= 1.0), lattice (>= 0.20), methods

**RoxygenNote** 7.0.2

**NeedsCompilation** no

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**Repository** CRAN

**Date/Publication** 2019-12-12 23:10:02 UTC

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ALTopt-package

*Optimal Experimental Designs for Accelerated Life Testing***Description**

Creates the optimal (D, U and I) designs for the accelerated life testing with right censoring or interval censoring. It uses generalized linear model (GLM) approach to derive the asymptotic variance-covariance matrix of regression coefficients. The failure time distribution is assumed to follow Weibull distribution with a known shape parameter and log-linear link functions are used to model the relationship between failure time parameters and stress variables. The acceleration model may have multiple stress factors, although most ALTs involve only two or less stress factors. ALTopt package also provides several plotting functions including contour plot, Fraction of Use Space (FUS) plot and Variance Dispersion graphs of Use Space (VDUS) plot. For more details, see Seo and Pan (2015) <doi:10.32614/RJ-2015-029>.

**Details**

```

Package:      ALTopt
Version:      0.1.2
Authors@R:    as.person(c( "Kangwon Seo <seoka@missouri.edu> [aut, cre]", "Rong Pan <rong.pan@asu.edu> [aut]" ))
Depends:      R (>= 3.0.0)
License:      GPL-3
LazyData:     true
Imports:      cubature (>= 1.0), lattice (>= 0.20), methods
Built:        R 3.6.1; ; 2019-12-12 12:30:00 UTC; windows

```

**Index:**

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altopt.ic	Optimal design with interval censoring.
altopt.rc	Optimal design with right censoring.
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design.plot	Design plot.
pv.contour.ic	Contour plot of prediction variance for a design with interval censoring.
pv.contour.rc	Contour plot of prediction variance for a design with right censoring.
pv.fus.ic	FUS (Fraction of Use Space) plot for interval censoring.
pv.fus.rc	FUS (Fraction of Use Space) plot for right censoring.
pv.vdus.ic	VDUS (Variance Dispersion of Use Space) plot for interval censoring.
pv.vdus.rc	VDUS (Variance Dispersion of Use Space) plot for right censoring.

### Author(s)

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### References

Seo, K. and Pan, R. (2015) ALTopt: An R Package for Optimal Experimental Design of Accelerated Life Testing. *The R Journal*, **7(2)**, 177-188.

Monroe, E. M., Pan, R., Anderson-Cook, C. M., Montgomery, D. C. and Borror C. M. (2011) A Generalized Linear Model Approach to Designing Accelerated Life Test Experiments, *Quality and Reliability Engineering International* **27(4)**, 595-607

Yang, T., Pan, R. (2013) A Novel Approach to Optimal Accelerated Life Test Planning With Interval Censoring, *Reliability, IEEE Transactions on* **62(2)**, 527-536

### See Also

[altopt.rc](#), [altopt.ic](#), [alteval.rc](#), [alteval.ic](#), [pv.contour.rc](#), [pv.contour.ic](#), [pv.fus.rc](#), [pv.fus.ic](#), [pv.vdus.rc](#), [pv.vdus.ic](#), [compare.fus](#), [compare.vdus](#), [design.plot](#), [convert.stress.level](#)

### Examples

```
# D optimal design of two stress factors with right censoring.
Design.D <- altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

design.plot(Design.D$opt.design.rounded, x1, x2)

pv.contour.rc(Design.D$opt.design.rounded, x1, x2, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useCond = c(1.758, 3.159))
```

```
FUS.D <- pv.fus.rc(Design.D$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# U optimal design of two stress factors with right censoring.
Design.U <- altopt.rc("U", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

design.plot(Design.U$opt.design.rounded, x1, x2)

pv.contour.rc(Design.U$opt.design.rounded, x1, x2, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useCond = c(1.758, 3.159))

FUS.U <- pv.fus.rc(Design.U$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# Comparing D and U optimal design.
compare.fus(FUS.D, FUS.U)
```

---

alteval.ic

*Design evaluation with interval censoring.*

---

## Description

[alteval.ic](#) calculates the objective function value (D, U or I) for a given design with interval censoring plan.

## Usage

```
alteval.ic(
  designTable,
  optType,
  t,
  k,
  nf,
  alpha,
  formula,
  coef,
  useCond,
  useLower,
  useUpper
)
```

**Arguments**

designTable	a data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altopt.rc</a> or <a href="#">altopt.ic</a> or any design matrix with the same form as those can be provided for this argument.
optType	the choice of "D", "U" and "I" optimality.
t	the total testing time.
k	the number of time intervals.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useCond	the numeric vector of use condition. It should be provided when optType is "U". The length of the vector should be same as the number of stress factors.
useLower	the numeric vector of lower bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.
useUpper	the numeric vector of upper bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.

**Value**

The objective function value corresponded by optType for a given design with interval censoring plan.

**See Also**

[altopt.ic](#)

**Examples**

```
# Evaluation of factorial design for interval censoring.
x1 <- c(0, 1, 0, 1)
x2 <- c(0, 0, 1, 1)
allocation <- c(25, 25, 25, 25)
facDes <- data.frame(x1, x2, allocation)

alteval.ic(facDes, "D", 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

alteval.ic(facDes, "U", 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

alteval.ic(facDes, "I", 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))
```

---

 alteval.rc

*Design evaluation with right censoring.*


---

### Description

`alteval.rc` calculates the objective function value (D, U or I) for a given design with right censoring plan.

### Usage

```
alteval.rc(
  designTable,
  optType,
  tc,
  nf,
  alpha,
  formula,
  coef,
  useCond,
  useLower,
  useUpper
)
```

### Arguments

<code>designTable</code>	a data frame containing the coordinates and the number of allocation of each design point. The design created by either <code>altopt.rc</code> or <code>altopt.ic</code> or any design matrix with the same form as those can be provided for this argument.
<code>optType</code>	the choice of "D", "U" and "I" optimality.
<code>tc</code>	the censoring time.
<code>nf</code>	the number of stress factors.
<code>alpha</code>	the value of the shape parameter of Weibull distribution.
<code>formula</code>	the object of class formula which is the linear predictor model.
<code>coef</code>	the numeric vector containing the coefficients of each term in formula.
<code>useCond</code>	the numeric vector of use condition. It should be provided when <code>optType</code> is "U". The length of the vector should be same as the number of stress factors.
<code>useLower</code>	the numeric vector of lower bound of use region. It should be provided when <code>optType</code> is "I". The length of the vector should be same as the number of stress factors.
<code>useUpper</code>	the numeric vector of upper bound of use region. It should be provided when <code>optType</code> is "I". The length of the vector should be same as the number of stress factors.

**Value**

The objective function value corresponded by optType for a given design with right censoring plan.

**See Also**

[altopt.rc](#)

**Examples**

```
# Evaluation of factorial design for right censoring.
x1 <- c(0, 1, 0, 1)
x2 <- c(0, 0, 1, 1)
allocation <- c(25, 25, 25, 25)
facDes <- data.frame(x1, x2, allocation)

alteval.rc(facDes, "D", 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

alteval.rc(facDes, "U", 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

alteval.rc(facDes, "I", 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))
```

---

altopt.ic

*Optimal design with interval censoring.*

---

**Description**

[altopt.ic](#) creates D, U or I optimal design of the accelerated life testing with interval censoring plan.

**Usage**

```
altopt.ic(
  optType,
  N,
  t,
  k,
  nf,
  alpha,
  formula,
  coef,
  useCond,
  useLower,
  useUpper,
  nOpt = 1,
  nKM = 30,
```

```

    nCls = NULL
  )

```

### Arguments

optType	the choice of "D", "U" and "I" optimality.
N	the number of test units.
t	the total testing time.
k	the number of time intervals.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useCond	the numeric vector of use condition. It should be provided when optType is "U". The length of the vector should be same as the number of stress factors.
useLower	the numeric vector of lower bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.
useUpper	the numeric vector of upper bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.
nOpt	the number of repetition of optimization process. Default is 1.
nKM	the number of repetition of k-means clustering. Default is 20.
nCls	the number of clusters used for k-means clustering. If not specified, it is set as the number of parameters in the linear predictor model.

### Value

A list with components

- call: the matched call.
- opt.design.ori: the original optimal design.
- opt.value.ori: the objective function value of opt.design.ori.
- opt.design.rounded: the optimal design clustered by rounding in third decimal points.
- opt.value.rounded: the objective function value of opt.design.rounded.
- opt.design.kmeans: the optimal design clustered by `kmeans`.
- opt.value.kmeans: the objective function value of opt.design.kmeans.

### References

- Monroe, E. M., Pan, R., Anderson-Cook, C. M., Montgomery, D. C. and Borror C. M. (2011) A Generalized Linear Model Approach to Designing Accelerated Life Test Experiments, *Quality and Reliability Engineering International* **27(4)**, 595–607
- Yang, T., Pan, R. (2013) A Novel Approach to Optimal Accelerated Life Test Planning With Interval Censoring, *Reliability, IEEE Transactions on* **62(2)**, 527–536



**See Also**

[kmeans](#), [alteval.ic](#)

**Examples**

```
## Not run:
# Generating D optimal design for interval censoring.
altopt.ic("D", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

# Generating U optimal design for interval censoring.
altopt.ic("D", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

# Generating I optimal design for interval censoring.
altopt.ic("D", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859),
useUpper = c(2.058, 3.459))

## End(Not run)
```

---

altopt.rc

*Optimal design with right censoring.*

---

**Description**

[altopt.rc](#) creates D, U or I optimal design of the accelerated life testing with right censoring plan.

**Usage**

```
altopt.rc(
  optType,
  N,
  tc,
  nf,
  alpha,
  formula,
  coef,
  useCond,
  useLower,
  useUpper,
  nOpt = 1,
  nKM = 30,
  nCls = NULL
)
```

**Arguments**

optType	the choice of "D", "U" and "I" optimality.
N	the number of test units.
tc	the censoring time.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useCond	the numeric vector of use condition. It should be provided when optType is "U". The length of the vector should be same as the number of stress factors.
useLower	the numeric vector of lower bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.
useUpper	the numeric vector of upper bound of use region. It should be provided when optType is "I". The length of the vector should be same as the number of stress factors.
nOpt	the number of repetition of optimization process. Default is 1.
nKM	the number of repetition of k-means clustering. Default is 20.
nCls	the number of clusters used for k-means clustering. If not specified, it is set as the number of parameters in the linear predictor model.

**Value**

A list with components

- call: the matched call.
- opt.design.ori: the original optimal design.
- opt.value.ori: the objective function value of opt.design.ori.
- opt.design.rounded: the optimal design clustered by rounding in third decimal points.
- opt.value.rounded: the objective function value of opt.design.rounded.
- opt.design.kmeans: the optimal design clustered by [kmeans](#).
- opt.value.kmeans: the objective function value of opt.design.kmeans.

**References**

Monroe, E. M., Pan, R., Anderson-Cook, C. M., Montgomery, D. C. and Borror C. M. (2011) A Generalized Linear Model Approach to Designing Accelerated Life Test Experiments, *Quality and Reliability Engineering International* **27(4)**, 595–607

Yang, T., Pan, R. (2013) A Novel Approach to Optimal Accelerated Life Test Planning With Interval Censoring, *Reliability, IEEE Transactions on* **62(2)**, 527–536

**See Also**

[kmeans](#), [alteval.rc](#)

**Examples**

```
## Not run:
# Generating D optimal design for right censoring.
altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

# Generating U optimal design for right censoring.
altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

# Generating I optimal design for right censoring.
altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859),
useUpper = c(2.058, 3.459))

## End(Not run)
```

---

compare.fus

*Comparing designs using FUS*


---

**Description**

[compare.fus](#) draws the FUS plots of multiple designs on a single frame.

**Usage**

```
compare.fus(...)
```

**Arguments**

... Objects created by [pv.fus.rc](#) or [pv.fus.ic](#).

**Value**

FUS plots of multiple designs.

**See Also**

[pv.fus.rc](#), [pv.fus.ic](#)

**Examples**

```
## Not run:
# Generating D optimal design and FUS plot.
Dopt <- altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

FUS.D <- pv.fus.rc(Dopt$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
```

```

useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# Generating U optimal design and FUS plot.
Uopt <- altoprt.rc("U", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

FUS.U <- pv.fus.rc(Uopt$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# Comparing D and U optimal designs.
compare.fus(FUS.D, FUS.U)

## End(Not run)

```

---

compare.vdus

*Comparing designs using VDUS*

---

## Description

[compare.vdus](#) draws the VDUS plots of multiple designs on a single frame.

## Usage

```
compare.vdus(...)
```

## Arguments

... Objects created by [pv.vdus.rc](#) or [pv.vdus.ic](#).

## Value

VDUS plots of multiple designs.

## See Also

[pv.vdus.rc](#), [pv.vdus.ic](#)

## Examples

```

## Not run:
# Generating D optimal design and VDUS plot.
Dopt <- altoprt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

VDUS.D <- pv.vdus.rc(Dopt$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# Generating U optimal design and VDUS plot.

```

```

Uopt <- altoprt.rc("U", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

VDUS.U <- pv.vdus.rc(Uopt$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

# Comparing D and U optimal designs.
compare.vdus(VDUS.D, VDUS.U)

## End(Not run)

```

---

convert.stress.level *Coding and decoding stress level*

---

## Description

Convert the stress levels from the actual levels to standardized levels, and vice versa.

## Usage

```
convert.stress.level(lowStLv, highStLv, actual = NULL, stand = NULL)
```

## Arguments

lowStLv	a numeric vector containing the actual lowest stress level of each stress variable in design region.
highStLv	a numeric vector containing the actual highest stress level of each stress variable in design region.
actual	a data frame or numeric vector containing the design points in actual units.
stand	a data frame or numeric vector containing the design points in standardized units.

## Value

When actual is provided, the function converts it to the standardized units and when stand is provided, the function converts it to the actual units.

## Examples

```

## Not run:
# Generating D optimal design in coded unit.
Design <- altoprt.rc(optType = "D", N = 100, tc = 100, nf = 2, alpha = 1,
formula = ~x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01))

# Transform the coded unit to actual stress variable's level.
convert.stress.level(lowStLv = c(34.834, 4.094), highStLv = c(30.288, 4.5),
stand = Design$opt.design.rounded)

```

```
# Transform the actual stress level to coded units.
use <- c(38.281, 3.219)
convert.stress.level(lowStLv = c(34.834, 4.094), highStLv = c(30.288, 4.5),
actual = use)

## End(Not run)
```

---

design.plot

*Design plot.*

---

### Description

`design.plot` draws design plot as a form of a bubble plot of any two stress factors which are specified by `xAxis` and `yAxis`. The size of each bubble indicates the relative magnitude of allocation on each design point.

### Usage

```
design.plot(design, xAxis, yAxis)
```

### Arguments

<code>design</code>	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <code>altopt.rc</code> or <code>altopt.ic</code> or any design matrix with the same form as those can be provided for this argument.
<code>xAxis</code>	the name of the factor to be displayed in x axis.
<code>yAxis</code>	the name of the factor to be displayed in y axis.

### Value

The bubble plot of a design with two stress factors.

### Examples

```
## Not run:
# Design plot of D optimal design with right censoring.
Design1 <- altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01))

design.plot(Design1$opt.design.rounded, x1, x2)

## End(Not run)
```

---

pv.contour.ic	<i>Contour plot of prediction variance for a design with interval censoring.</i>
---------------	--

---

### Description

[pv.contour.ic](#) draws the contour plot of prediction variance for a given design with interval censoring plan. Either useCond or use region (useLower and useUpper) should be provided.

### Usage

```
pv.contour.ic(
  design,
  xAxis,
  yAxis,
  t,
  k,
  nf,
  alpha,
  formula,
  coef,
  useCond = NULL,
  useLower = NULL,
  useUpper = NULL
)
```

### Arguments

design	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altppt.rc</a> or <a href="#">altppt.ic</a> or any design matrix with the same form as those can be provided for this argument.
xAxis	the name of the factor to be displayed in x axis.
yAxis	the name of the factor to be displayed in y axis.
t	the total testing time.
k	the number of time intervals.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useCond	the vector of specified use condition. If it is provided, the contour line will be generated up to this point.
useLower, useUpper	the vector of the use region. If these are provided, the contour line will be generated up to this region. Note that either useCond or both of useLower, useUpper should be provided.

**Value**

The contour plot of prediction variance for interval censoring.

**See Also**

[altopt.ic](#)

**Examples**

```
## Not run:
# Contour plot of prediction variance of U optimal design with interval censoring.
Design <- altopt.ic("D", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
  coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

pv.contour.ic(Design$opt.design.rounded, x1, x2, 30, 5, 2, 1,
  formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

## End(Not run)
```

---

pv.contour.rc

*Contour plot of prediction variance for a design with right censoring.*

---

**Description**

[pv.contour.rc](#) draws the contour plot of prediction variance for a given design with right censoring plan. Either useCond or use region (useLower and useUpper) should be provided.

**Usage**

```
pv.contour.rc(
  design,
  xAxis,
  yAxis,
  tc,
  nf,
  alpha,
  formula,
  coef,
  useCond = NULL,
  useLower = NULL,
  useUpper = NULL
)
```



**Arguments**

design	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altopt.rc</a> or <a href="#">altopt.ic</a> or any design matrix with the same form as those can be provided for this argument.
xAxis	the name of the factor to be displayed in x axis.
yAxis	the name of the factor to be displayed in y axis.
tc	the censoring time.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useCond	the vector of specified use condition. If it is provided, the contour line will be generated up to this point.
useLower, useUpper	the vector of the use region. If these are provided, the contour line will be generated up to this region. Note that either useCond or both of useLower, useUpper should be provided.

**Value**

The contour plot of prediction variance for right censoring.

**See Also**

[altopt.rc](#)

**Examples**

```
## Not run:
# Contour plot of prediction variance of U optimal design with right censoring.
Design <- altopt.rc("D", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

pv.contour.rc(Design$opt.design.rounded, x1, x2, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01), useCond = c(1.758, 3.159))

## End(Not run)
```

---

`pv.fus.ic`*FUS (Fraction of Use Space) plot for interval censoring.*

---

### Description

`pv.fus.ic` draws the FUS plot of prediction variance for a given design with interval censoring plan. The use region (`useLower` and `useUpper`) should be provided.

### Usage

```
pv.fus.ic(  
  design,  
  t,  
  k,  
  nf,  
  alpha,  
  formula,  
  coef,  
  useLower = NULL,  
  useUpper = NULL  
)
```

### Arguments

<code>design</code>	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <code>altpopt.rc</code> or <code>altpopt.ic</code> or any design matrix with the same form as those can be provided for this argument.
<code>t</code>	the total testing time.
<code>k</code>	the number of time intervals.
<code>nf</code>	the number of stress factors.
<code>alpha</code>	the value of the shape parameter of Weibull distribution.
<code>formula</code>	the object of class <code>formula</code> which is the linear predictor model.
<code>coef</code>	the numeric vector containing the coefficients of each term in <code>formula</code> .
<code>useLower, useUpper</code>	the vectors containing the lower bound and upper bound for the use region. They should be provided for FUS plot.

### Value

The "trellis" object which includes the FUS plot for interval censoring.

### See Also

[altpopt.ic](#)

**Examples**

```
## Not run:
# FUS plot of I optimal design with interval censoring.
Design <- altopt.ic("I", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

pv.fus.ic(Design$opt.design.rounded, 30, 5, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

## End(Not run)
```

---

pv.fus.rc

*FUS (Fraction of Use Space) plot for right censoring.*


---

**Description**

[pv.fus.rc](#) draws the FUS plot of prediction variance for a given design with right censoring plan. The use region (useLower and useUpper) should be provided.

**Usage**

```
pv.fus.rc(
  design,
  tc,
  nf,
  alpha,
  formula,
  coef,
  useLower = NULL,
  useUpper = NULL
)
```

**Arguments**

design	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altopt.rc</a> or <a href="#">altopt.ic</a> or any design matrix with the same form as those can be provided for this argument.
tc	the censoring time.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useLower, useUpper	the vectors containing the lower bound and upper bound for the use region. They should be provided for FUS plot.

**Value**

The "trellis" object which includes the FUS plot for right censoring.

**See Also**

[altopt.rc](#)

**Examples**

```
## Not run:
# FUS plot of I optimal design with right censoring.
Design <- altopt.rc("I", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

pv.fus.rc(Design$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

## End(Not run)
```

---

pv.vdus.ic

*VDUS (Variance Dispersion of Use Space) plot for interval censoring.*

---

**Description**

[pv.vdus.ic](#) draws the VDUS plot of prediction variance for a given design with interval censoring plan. The use region (useLower and useUpper) should be provided.

**Usage**

```
pv.vdus.ic(
  design,
  t,
  k,
  nf,
  alpha,
  formula,
  coef,
  useLower = NULL,
  useUpper = NULL
)
```

**Arguments**

design	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altopt.rc</a> or <a href="#">altopt.ic</a> or any design matrix with the same form as those can be provided for this argument.
t	the total testing time.

**k** the number of time intervals.  
**nf** the number of stress factors.  
**alpha** the value of the shape parameter of Weibull distribution.  
**formula** the object of class formula which is the linear predictor model.  
**coef** the numeric vector containing the coefficients of each term in formula.  
**useLower, useUpper** the vectors containing the lower bound and upper bound for the use region. They should be provided for VDUS plot.

### Value

The "trellis" object which includes the VDUS plot for interval censoring.

### See Also

[altopt.ic](#)

### Examples

```

## Not run:
# VDUS plot of I optimal design with interval censoring.
Design <- altopt.ic("I", 100, 30, 5, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

pv.vdus.ic(Design$opt.design.rounded, 30, 5, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

## End(Not run)

```

---

pv.vdus.rc

*VDUS (Variance Dispersion of Use Space) plot for right censoring.*

---

### Description

[pv.vdus.rc](#) draws the VDUS plot of prediction variance for a given design with right censoring plan. The use region (useLower and useUpper) should be provided.

### Usage

```

pv.vdus.rc(
  design,
  tc,
  nf,
  alpha,
  formula,
  coef,

```

```

    useLower = NULL,
    useUpper = NULL
  )

```

### Arguments

design	the data frame containing the coordinates and the number of allocation of each design point. The design created by either <a href="#">altopt.rc</a> or <a href="#">altopt.ic</a> or any design matrix with the same form as those can be provided for this argument.
tc	the censoring time.
nf	the number of stress factors.
alpha	the value of the shape parameter of Weibull distribution.
formula	the object of class formula which is the linear predictor model.
coef	the numeric vector containing the coefficients of each term in formula.
useLower, useUpper	the vectors containing the lower bound and upper bound for the use region. They should be provided for VDUS plot.

### Value

The "trellis" object which includes the VDUS plot for right censoring.

### See Also

[altopt.rc](#)

### Examples

```

## Not run:
# VDUS plot of I optimal design with right censoring.
Design <- altopt.rc("I", 100, 100, 2, 1, formula = ~ x1 + x2 + x1:x2,
coef = c(0, -4.086, -1.476, 0.01), useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

pv.vdus.rc(Design$opt.design.rounded, 100, 2, 1,
formula = ~ x1 + x2 + x1:x2, coef = c(0, -4.086, -1.476, 0.01),
useLower = c(1.458, 2.859), useUpper = c(2.058, 3.459))

## End(Not run)

```

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