Package 'uncertainty'

October 12, 2022

Type Package

Title Uncertainty Estimation and Contribution Analysis

Version 0.2.0

Date 2018-05-04

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Description Implements the Gaussian method of first and second order, the Kragten numerical method and the Monte Carlo simulation method for uncertainty estimation and analysis.

Depends graphics (>= 3.4.0), stats (>= 3.4.0), mvtnorm (>= 0.9), triangle (>= 0.7), R (>= 3.4.0)

License GPL (>= 2)

Encoding UTF-8

NeedsCompilation no

Repository CRAN

Date/Publication 2018-05-06 20:15:11 UTC

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uncertainty-package *Uncertainty Estimation and Contribution Analysis*

Description

Uncertainty estimation and contribution analysis implemented by 4 methods: the Gaussian method of first, the Gaussian method of second order, the Kragten numerical method and the Monte Carlo simulation method

Details

Package:	uncertainty
Type:	Package
Version:	0.1.1
Date:	2014-06-12
License:	GPL (>=2)

Define an "uncertainty budget" object, including all the involved variables. Then estimate the "uncertainty" object by defining a measurand model, using the "uncertainty budget" and applying an estimation method. Print or plot the measurand estimates or create a "summary uncertainty" object to print or plot the uncertainty contributions to the measurand model.

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

uncertaintyBudget, print.uncertaintyBudget, uncertainty, print.uncertainty, plot.uncertainty, summary.uncertainty, print.summary.uncertainty, plot.summary.uncertainty

Examples

```
require(mvtnorm)

cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)
```

```
u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")), y=cor.mat)
u.budget


## Gaussian first order estimates
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO",
measurand_label=expression(ratio[GFO]),
measurand_model="x0/x1",
method="GFO", alpha=0.05))

contr.GFO<- summary.uncertainty(GFO.res)

## Monte Carlo estimates
MC.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.MC",
measurand_label=expression(ratio[MC]),
measurand_model="x0/x1",
method="MC", alpha=0.05, B=1e5))

contr.MC<- summary.uncertainty(MC.res)

## print the estimates
MC.res
GFO.res

## print the uncertainty summary
contr.MC
contr.GFO

## Displaying both estimated distributions
## Not run:
plot(MC.res, col=4, xlab=MC.res$measurand_model)
plot(GFO.res, lty=2, col=2, add=T)
legend(0.7, 2.5, legend=c("Monte Carlo", "Gaussian First Order"),
lty=c(1,2), col=c(4,2), lwd=2, bg="white")

## End(Not run)

## Display both uncertainty summaries

## Not run:
barplot(cbind(contr.GFO$budget$contrib, contr.MC$budget$contrib),
beside=TRUE, horiz=TRUE, main="Uncertainty contribution by method",
xlab="percent Variance",
names.arg=c(GFO.res$measurand_label, MC.res$measurand_label))

## End(Not run)

##########################
```

```
## Example H.1 from GUM ##
##########################

# define the uncertainty budget

u.budget<- uncertaintyBudget(
  x=list(
    name=c("lambda.s", "alpha.s", "theta.bar", "Delta", "delta.alpha",
    "delta.theta", "d.bar", "d.cr",
"d.cnr"),
    label=c("lambda[s]", "alpha[s]", "bar(theta)", "Delta", "delta[alpha]",
    "delta[theta]", "bar(d)", "d[cr]", "d[cnr]"),
    mean=c(50.000623,11.5e-6,-1e-1, 0, 0, 0, 2.15e-4, 0, 0),
    units=c("mm", "oC^-1","oC","oC", "oC^-1", "oC", "mm", "mm", "mm"),
    u=c(25e-6, 1.2e-6, 0.2, 0.35, 0.58e-6, 0.029, 5.8e-6, 3.9e-6, 6.7e-6),
    distribution=c("t","unif","unif","arcsine","unif","unif","t","t","t"),
    dof=c(18, 1, 1, 1, 50, 2, 24, 5, 8)
  ),
  y=diag(1, 9)
)

# define the measurand
measurand_name<- "lambda"
measurand_label<- "lambda"
measurand_model<- paste("(lambda.s*(1+alpha.s*(theta.bar+Delta+delta.theta))",
"+d.bar+d.cr+d.cnr)/(1+(alpha.s+delta.alpha)*(theta.bar+Delta))", sep="")

# estimate the measurand using the Gaussian First Order method (GUM)

u.GFO<- uncertainty(
x=u.budget,
y=list(measurand_name=measurand_name,
measurand_label=measurand_label,
measurand_model=measurand_model,
alpha=0.01,
method="GFO"
)
)

u.GFO
# same result as reported in Table H.1

# estimate the measurand using the Gaussian Second Order method

u.GSO<- uncertainty(
x=u.budget,
y=list(measurand_name=measurand_name,
measurand_label=measurand_label,
measurand_model=measurand_model,
alpha=0.01,
method="GSO"
)
)
```

```
u.GSO
# same results as reported in section H.1.6, U(99) = 93 nm,
# the difference is due to rounding error.
# u = 34 nm, but dof are updated to 21 instead of keeping 16.

# estimate the measurand using the Monte Carlo method (GUM supplement 1)

u.MC<- uncertainty(
x=u.budget,
y=list(measurand_name=measurand_name,
measurand_label=measurand_label,
measurand_model=measurand_model,
alpha=0.01,
method="MC", B=1e6
)
)

u.MC
# this result is not reported in the GUM

# estimate the measurand using the Kragten method

u.Kragten<- uncertainty(
x=u.budget,
y=list(measurand_name=measurand_name,
measurand_label=measurand_label,
measurand_model=measurand_model,
alpha=0.01,
method="Kragten"
)
)

u.Kragten
# same as GFO results
```

`plot.summary.uncertainty` *Plots an uncertainty summary. It shows the uncertainty contribution from each involved quantity*

Description

Builds a barplot with a bar for each source of uncertainty. If correlation is present then an additional entry is added. The current metric used to display is When correlation is present its contribution may be negative.

Usage

```
## S3 method for class 'summary.uncertainty'
plot(x, y = NULL, ...)
```

Arguments

x	an uncertainty summary object
y	not used.
...	additional parameters to customize the plot

Details

none

Value

None (invisible NULL)

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method.*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

See Also

summary.uncertainty, plot

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)

# estimate the measurand uncertainty using an uncertainty budget,
# a measurand definition and a selected estimating method.
```

```
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

# create an uncertainty summary object
GFO.sum<- summary(GFO.res)

# display the chart
## Not run: plot(GFO.sum)
```

`plot.uncertainty` *Plots a probability density function related to the measurand model*

Description

Plot a probability density function attributed to the measurand, depending on the selected method to estimate the uncertainty.

Usage

```
## S3 method for class 'uncertainty'
plot(x, y = NULL, xlab = parse(text = x$measurand_label),
main = "", ylab = "Probability density", from = x$mean - 4 * x$u, to = x$mean + 4 * x$u,
lwd = 2, add = FALSE, ...)
```

Arguments

`x`	An uncertainty object
`y`	not used, exists only for compatibility with the S3 generic function.
`xlab`	string or expression, label for the x-axis.
`main`	string or expression, label for the plot.
`ylab`	string or expression, label for the y-axis.
`from`	numeric, lower value of the x-axis to display.
`to`	numeric, upper valur of the x-axis to display.
`lwd`	numeric, line width.
`add`	logic, decides to add the curve into an existing plot or to create a new plot.
`...`	additional parameters.

Details

none

Value

None (invisible NULL)

Note

none

Author(s)

H. Gasca-Aragon

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

See Also

uncertainty.default, plot

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)

# estimate the measurand uncertainty using an uncertainty budget,
# a measurand definition and a selected estimating method.
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

# plot the estimated pdf of the measurand
## Not run: plot(GFO.res)
```

---

print.summary.uncertainty

Displays a list with the uncertainty contribution from each input quantity

---

Description

For each input quantity (source of uncertainty) it shows the uncertainty contribution, measured in percent of variance of the measurand model.

Usage

```
## S3 method for class 'summary.uncertainty'
print(x, ...)
```

Arguments

x	An uncertainty summary object
...	Additional parameters

Details

none

Value

None (invisible NULL)

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

summary.uncertainty, print

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)
u.budget

# estimate the measurand uncertainty using an uncertainty budget,
```

```
# a measurand definition and a selected estimating method.
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

GFO.res

# create an uncertainty summary object
GFO.sum<- summary(GFO.res)

# implicit call to the print method
GFO.sum

# same as
print(GFO.sum)

# uncertainty summary structure
attributes(GFO.sum)
```

`print.uncertainty` *Displays the detailed content of a measurand model including its uncertainty estimate.*

Description

Displays the estimated value of the measurand, its standard deviation, its standard uncertainty, the degrees of freedom and the significance level and an CI with that significance level.

Usage

```
## S3 method for class 'uncertainty'
print(x, ...)
```

Arguments

`x`	an uncertainty object
`...`	additional parameters

Details

none

Value

None (invisible NULL)

Note

none

Author(s)

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Maintainer: H. Gasca-Aragon <hugo_gasca_aragon@hotmail.com>

References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

uncertainty.default, print

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)
u.budget

# estimate the measurand uncertainty using an uncertainty budget,
# a measurand definition and a selected estimating method.
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

# implicit call to print method
GFO.res

# same as
print(GFO.res)

# structure of an uncertainty estimation object
attributes(GFO.res)
```

---

print.uncertaintyBudget

Prints an uncertainty budget object

Description

Print the description of each uncertainty source

Usage

```
## S3 method for class 'uncertaintyBudget'
print(x, ...)
```

Arguments

x	an uncertainty budget object
...	additional parameters

Details

none

Value

None (invisible NULL)

Note

none

Author(s)

H. Gasca-Aragon

Maintainer: H. Gasca-Aragon <hugo_gasca_aragon@hotmail.com>

References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

uncertaintyBudget.default, print

Examples

```
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)

# implicitly calls the print method
u.budget
```

```
# same as
print(u.budget)

# uncertainty budget structure
attributes(u.budget)
```

`summary.uncertainty` *Creates an uncertainty summary object*

Description

Performs an uncertainty contribution estimation for the uncertainty object. The metric used to measure the contribution is percent of variance. If correlation is present an additional entry is shown with the whole contribution due to correlated input quantities.

Usage

```
## S3 method for class 'uncertainty'
summary(object, ndigits = 3, ...)
```

Arguments

`object`	an uncerainty object
`ndigits`	numeric, the number of digits for displaying.
`...`	additional parameters

Details

none

Value

An uncertainty summary object:

`call`	the call invocation
`measurand.name`	name of the measurand
`measurand.label`	label of the measurand for displaying purposes
`budget`	a list with the name, mean, label, u(uncertainty), dof and uncertainty contribution for each input quantity plus a correlation entry if any

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

See Also

uncertainty.default, print.summary.uncertainty, summary

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)
u.budget

# estimate the measurand uncertainty using an uncertainty budget,
# a measurand definition and a selected estimating method.
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

GFO.res

# create an uncertainty summary object
GFO.sum<- summary(GFO.res)

# implicit call to the print method
GFO.sum

# same as
print(GFO.sum)

# uncertainty summary structure
attributes(GFO.sum)
```

`uncertainty` *Creates an uncertainty object*

Description

Builds an uncertainty estimation object using a measurand model and an uncertainty budget object

Usage

```
uncertainty(x, ...)
```

Arguments

`x`	an uncertainty budget object
`...`	additional parameters

Details

Creates an uncertainty estimation object. Uses an uncertainty budget object to estimate the expected value and uncertainty of a measurand by applying a selected estimation method.

Value

An uncertainty estimation object

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

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Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

`uncertainty.default`

`uncertainty.default` *Generic function for calling an uncertainty object*

Description

Creates an uncertainty estimation object using a measurand model and an uncertainty budget object

Usage

```
## Default S3 method:
uncertainty(x, y, ...)
```

Arguments

`x`	an uncertainty budget object
`y`	a list with the measurand description and selected estimation method, the measurand description includes: measurand_name, measurand_model, measurand_label, alpha (significance level), method and method parameters. the valid methods are: GFO, GSO, MC, Kragten. currently the only method parameter implemented is the number of simulated samples (B) for the method MC.
`...`	additional parameters

Details

Creates an uncertainty estimation object. Uses an uncertainty budget object to estimate the expected value and uncertainty of a measurand by applying a selected estimation method.

Value

An uncertainty estimation object with the structure: `method` selected estimating method, `call` current call invocation, `uncertaintyBudget` an uncertainty budget object, `measurand` name, label, model describing the measurand, `mean` the estimated mean, `sd` the estimated standard deviation, `u` the estimated standard uncertainty, `alpha` the significante level used in the estimation, `dof` the estimated degrees of freedom, `U` the estimated expanded uncertainty, `lcl` the lower confidence interval, `ucl` the upper confidence interval, `variables` a vector with the input quantities, `contribution` a vector with the uncertainty contributions, `cor.contribution` the uncertainty contribution due to overall correlation, `partial` a vector of the partial derivatives of the measurand.model with respect to each input quantity, `coeff` a vector of the sensibility coefficients for each input quantity.

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

See Also

uncertainty, uncertaintyBudget.default, print.uncertainty, plot.uncertainty, summary.uncertainty

Examples

```
# create an uncertainty budget
cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")),
y=cor.mat)
u.budget

# estimate the measurand uncertainty using an uncertainty budget,
# a measurand definition and a selected estimating method.
GFO.res<- uncertainty(x=u.budget,
y=list(measurand_name="ratio.GFO", measurand_label="ratio[GFO]",
measurand_model="x0/x1", method="GFO", alpha=0.05))

GFO.res
```

---

uncertaintyBudget *Generic function for uncertainty budget object*

Description

Generic function for creating an uncertainty budget object

Usage

```
uncertaintyBudget(x, ...)
```

Arguments

x	a list with the vector entries name, label, mean, u(uncertainty), distribution and dof, one for each quantity.
...	additional parameters

Details

uncertaintyBudget is a generic function (under S3 protocol) for searching the default method.

Value

An uncertainty budget object with attributes:

`name` the name of each input quantity

`mean` the mean value of each input quantity

`u` the uncertainty of each input quantity

`dof` the degrees of freedom of each input quantity

`label` the label of each input quantity

`distribution` the distribution of each input quantity, valid values are (normal, unif, t, chisq, f, triangle, binomial, bernoulli, beta, gamma)

`cor` the correlation matrix among the input quantities

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

`uncertaintyBudget.default`

`uncertaintyBudget.default`
Generic function for calling an uncertainty budget object

Description

Creates an uncertainty budget.

Usage

```
## Default S3 method:
uncertaintyBudget(x, y, ...)
```

Arguments

x	a list with the vector entries name, label, mean, u(uncertainty), distribution and dof, one for each input quantity.
y	a correlation matrix of the input quantities, interpreted in the same order of input quantities as the vector name
...	additional parameters

Details

Creates an uncertainty budget object

Value

An uncertainty budget object with attributes:

`name` the name of each input quantity

`mean` the mean value of each input quantity

`u` the uncertainty of each input quantity

`dof`the degrees of freedom of each input quantity

`label`the label of each input quantity

`distribution` the distribution of each input quantity, valid values are (bernoulli, beta, binomial, cuachy, chisq, exp, f, gamma, lognormal, poission, normal, unif, t, traingular, weibull, arcsine)

`cor` the correlation matrix among the input quantities

Note

none

Author(s)

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References

JCGM 100:2008. *Guide to the expression of uncertainty of measurement*

JCGM 100:2005. *Supplement 1 Propagation of distributions usign a Monte Carlo method*

EURACHEM/CITAC Guide CG 4. *Quantifying Uncertainty in Analytical Measurement*

Becker, R.A., Chambers, J.M. and Wilks, A.R. (1988) *The New S Language*. Wadsworth & Brooks/Cole.

See Also

`uncertaintyBudget`, `uncertainty`, `print.uncertaintyBudget`

Examples

```
require(mvtnorm)

cor.mat<- matrix(c(1,-0.7,-0.7,1),2,2)

u.budget<- uncertaintyBudget(x=list(name=c("x0","x1"),
mean=c(10,20), u=c(1,5), dof=c(10,10),
label=c("x[0]", "x[1]"), distribution=c("normal","normal")), y=cor.mat)
u.budget
```

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