Package ‘rbcc’

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Type Package

Title Risk-Based Control Charts

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Description Univariate and multivariate versions of risk-based control charts. Univariate versions of control charts, such as the risk-based version of X-bar, Moving Average (MA), Exponentially Weighted Moving Average Control Charts (EWMA), and Cumulative Sum Control Charts (CUSUM) charts. The risk-based version of the multivariate T2 control chart. Plot and summary functions. Kosztyan et. al. (2016) <doi:10.1016/j.eswa.2016.06.019>.

License GPL (>= 2)

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URL https://github.com/kzst/rbcc

Depends R (>= 4.00)

Imports qcc, ggplot2, reshape2, PearsonDS, methods, pracma

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Contents

`rbcc-package` *Package of Risk-based Control Charts*

Description

The risk-based is a new methodology to design an optimized control chart that minimized the cost of decision outcomes of the control process. The basic purpose of the risk-based control is to determine the optimal control charts parameters to minimize the risks arising from measurement uncertainty. This article develops an R package for family of risk-based control charts, namely `'rbcc'`. In this package, the functions required in the design of family of risk-based control charts univariate and multivariate

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References

Katona, A. I., Saghir, A., Hegedűs, C., & Kosztyán, Z. T. (2023). Design of Risk-Based Univariate Control Charts with Measurement Uncertainty. IEEE Access.

Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

rbcc, data_gen, summary.rbcc, plot.rbcc.

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data_gen — *Data Generator for Risk-based Control Charts*

Description

data_gen function simulate the data set from a specified distribution used in the risk based control charts.

Usage

```
data_gen(obs, mu, va, sk, ku)
```

Arguments

obs	The total number of observations of a process(a numeric value).
mu	The means of p characteristics/measurement errors (a numeric vector).
va	The variances of p characteristics/measurement errors (a numeric vector).
sk	The skewness of distribution of p characteristics/measurement errors (a numeric vector).
ku	The kurtosis of distribution of p characteristics/measurement errors (a numeric vector).

Value

Return the data vector/matrix and the measurement error vector/matrix used in the risk-based control charts functions.

Author(s)

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References

Katona, A. I., Saghir, A., Hegedűs, C., & Kosztyán, Z. T. (2023). Design of Risk-Based Univariate Control Charts with Measurement Uncertainty. IEEE Access.

Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data Generation and Xbar chart.

## Example for generation of data vector X and measuremenet error vector UC.
obs <- 200                 # Total number of observations of a process.
mu_X <- c(0)               # Define data mean.
va_X  <- c(1)              # Define data standard deviation.
sk_X <- c(0)               # Define data skewness.
ku_X <- c(3)               # Define data kurtosis.
mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

# Simulation of 200 obervations of 1 variable.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Simulation of 200 muasurement erros related to 1 variable.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# Construction of risk-based Xbar chart with default vector of decision costs
C <- c(1,1,1,1)                           # vector of decision costs
H <- rbcc(X, UC, C, n=3, type="xbar")     # for subgroups of size 3
plot(H)                                   # plot RBCC

# optimal risk-based xbar control chart
H_opt <- rbcc_opt(X, UC, C, n=3, type="xbar")

# Data Generation and multivariate T2 chart.

# Data generation for a matrix X
mu_X <- c(0,1,2)           # vector of means.
va_X  <- c(1,2, 0.5)       # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)      # vector of skewness.
ku_X <- c(3,3.5, 4)        # vector of kurtosis.
obs <- 200                 # Total number of observations of a process.

# Example for generation of data matrix X of 200 obervations of 3 variables.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error matrix UC.
mu_UC <- c(0,0,0)         # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)      # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)         # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)         # Vector of kurtosis of measurement errors.

#Example for generation of measurement error matrix with 3 variables.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)                # vector of decision costs
H <- rbmcc(X, UC, C)           # for subgroups of size 1
```

```
plot(H)                        # plot RBMCC

# optimal risk-based multivariate control chart
H_opt <- rbmcc_opt(X, UC, C)

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbmcc(X, UC, C)           # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)              # vector of decision costs
H <- rbmcc(X, UC, C, 3)          # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3)  #optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

`plot.rbcc` *Plot function for Risk-based Control Charts*

Description

Plot function for Risk-based Univariate (shewhart, exponentially weighted moving average(EWMA), moving average (MA) and cumulative sum (CUSUM) or Multivariate Control Chart

Usage

```
## S3 method for class 'rbcc'
plot(x, ...)
## S3 method for class 'rbcusumcc'
plot(x, ...)
## S3 method for class 'rbmcc'
plot(x, ...)
```

Arguments

`x`	an object of class 'rbcc', 'rbcusumcc' or 'rbmcc'.
`...`	other graphical parameters.

Value

No return value, called for side effects

Author(s)

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, summary.rbcc.

Examples

```
# Data Generation and Xbar chart.

## Example for generation of data vector X and measuremenet error vector UC.
obs <- 200                 # Total number of observations of a process.
mu_X <- c(0)               # Define data mean.
va_X  <- c(1)              # Define data standard deviation.
sk_X <- c(0)               # Define data skewness.
ku_X <- c(3)               # Define data kurtosis.
mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

# Simulation of 200 obervations of 1 variable.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Simulation of 200 muasurement erros related to 1 variable.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# Construction of risk-based Xbar chart with default vector of decision costs
C <- c(1,1,1,1)                         # vector of decision costs
H <- rbcc(X, UC, C, n=3, type="xbar")      # for subgroups of size 3
plot(H)                                 # plot RBCC
```

```
# optimal risk-based xbar control chart
H_opt <- rbcc_opt(X, UC, C, n=3, type="xbar")

# Data Generation and multivariate T2 chart.
# Data generation for a matrix X
mu_X <- c(0,1,2)              # vector of means.
va_X  <- c(1,2, 0.5)          # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)         # vector of skewness.
ku_X <- c(3,3.5, 4)           # vector of kurtosis.
obs <- 200                    # Total number of observations of a process.

# Example for generation of data matrix X of 200 obervations of 3 variables.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error matrix UC.
mu_UC <- c(0,0,0)      # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)   # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)      # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)      # Vector of kurtosis of measurement errors.

# Example for generation of measurement error matrix of 3 variables.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)               # vector of decision costs
H <- rbmcc(X, UC, C)          # for subgroups of size 1
plot(H)                       # plot RBMCC

# optimal risk-based multivariate control chart
H_opt <- rbmcc_opt(X, UC, C)

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)         # vector of decision costs
H <- rbmcc(X, UC, C)        # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C) # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)            # vector of decision costs
H <- rbmcc(X, UC, C, 3)        # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3) # optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure
```

```
# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

---

rbcc *Risk-based Statistical Control Charts*

Description

Calculate Risk-based Shewhart type univarate Control Charts

Usage

```
rbcc (X, UC, C, n, type= c("xbar", "R", "S"), confidence_level=0.9973, K=3)
```

Arguments

X	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
UC	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
C	vector of decision costs (default value is vector of 1).
n	the sample size for grouping. For individual obervations use n=1).
type	a character string specifying the type of Shewhart control chart. Available types are; "Xbar", "R"and "S".
confidence_level	the (1-alpha)percent confidence level (default value is 0.99)
K	a correction component (default value is 3).

Value

cost0	Total cost of a monitoring process
cost1	Total cost of correct acceptance related to a process monitoring
cost2	Total cost of decision error type 1 related to a process monitoring
cost3	Total cost of decision error type 2 related to a process monitoring
cost4	Total cost of correct reject related to a process monitoring
LCLx	Lower control limit of a Shewhart univariate 'type' chart for a given data
UCLx	Upper control limit of a Shewhart univariate 'type' chart for a given data
LCLy	Lower control limit of a Shewhart univariate 'type' chart for a given data with measurement uncertainity
UCLy	Upper control limit of a Shewhart univariate 'type' chart for a given data with measurement uncertainity
real	Real values of a Shewhart univariate 'type' chart statistic
Observed	Observed values of a Shewhart univariate 'type' chart with measurement errors

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc_opt, rbcusumcc, rbcusumcc_opt,rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data Generation and Xbar chart.

## Example for generation of data vector X and measuremenet error vector UC.
obs <- 200                # Total number of observations of a process.
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
mu_UC <- c(0)             # Define mean of measurement errors.
va_UC <- c(1)             # Define standard deviation of measurement errors.
sk_UC <- c(0)             # Define skewness of measurement errors.
ku_UC <- c(3)             # Define kurtosis of measurement errors.

# Simulation of 200 obervations of 1 variable.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Simulation of 200 muasurement erros related to 1 variable.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# Construction of risk-based Xbar chart with default vector of decision costs
C <- c(1,1,1,1)                       # vector of decision costs
H <- rbcc(X, UC, C, n=3, type="xbar")   # for subgroups of size 3
plot(H)                               # plot RBCC

# optimal risk-based xbar control chart
H_opt <- rbcc_opt(X, UC, C, n=3, type="xbar")

# Data Generation and multivariate T2 chart.
# Data generation for a matrix X
mu_X <- c(0,1,2)              # vector of means.
va_X  <- c(1,2, 0.5)          # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)         # vector of skewness.
ku_X <- c(3,3.5, 4)           # vector of kurtosis.
```

```
obs <- 200                     # Total number of observations of a process.

# Example for generation of data matrix X of 200 obervations of 3 variables.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error matrix UC.
mu_UC <- c(0,0,0)       # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)    # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)       # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)       # Vector of kurtosis of measurement errors.

# Example for generation of measurement error matrix of 3 variables.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)                # vector of decision costs
H <- rbmcc(X, UC, C)           # for subgroups of size 1
plot(H)                        # plot RBMCC

# optimal risk-based multivariate control chart
H_opt <- rbmcc_opt(X, UC, C)
# with vector of proportional decision costs
C <- c(1, 5, 60, 5)         # vector of decision costs
H <- rbmcc(X, UC, C)        # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C) # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)           # vector of decision costs
H <- rbmcc(X, UC, C, 3)         # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3) # optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

`rbcc_opt` *Optimized Risk-based Univariate Control Charts*

Description

Calculate Optimized Risk-based Univariate Control Chart

Usage

```
rbcc_opt(X, UC, C, n, type=c("xbar", "R", "S"),confidence_level=0.9973,
K_init=0,LKL=0,UKL=5)
```

Arguments

`X`	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
`UC`	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
`C`	vector of decision costs (default value is vector of 1).
`n`	the sample size for grouping. For individual obervations use n=1).
`type`	a character string specifying the type of Shewhart control chart. Available types are; "Xbar", "R"and "S".
`confidence_level`	the (1-alpha)percent confidence level(default value is 0.9973)
`K_init`	a correction component (default value is 0).
`LKL`	Lower limit of K parameter (default value is 0)
`UKL`	Upper limit of K parameter (default value is 5)

Value

`cost0`	Total cost of a monitoring process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 2 related to a process monitoring
`cost3`	Total cost of decision error type 1 related to a process monitoring
`cost4`	Total cost of correct reject related to a process monitoring
`LCLx`	Lower Control Limit of a Shewhart univariate 'type' chart for a given data
`UCLx`	Upper Control Limit of a Shewhart univariate 'type' chart for a given data
`LCLy`	Lower Control Limit of an Optimal Risk-based univariate 'type' chart for a given data
`UCLy`	Upper Control Limit of an Optimal Risk-based univariate 'type' chart for a given data
`real`	Real values of plotting statistic for a given data
`Observed`	Observed plotting statistic for a given data with measurement errors
`par`	Optimal 'K' parameter of risk-based univariate 'type' chart

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data Generation and Xbar chart.

## Example for generation of data vector X and measuremenet error vector UC.
obs <- 200                  # Total number of observations of a process.
mu_X <- c(0)                # Define data mean.
va_X  <- c(1)               # Define data standard deviation.
sk_X <- c(0)                # Define data skewness.
ku_X <- c(3)                # Define data kurtosis.
mu_UC <- c(0)               # Define mean of measurement errors.
va_UC <- c(1)               # Define standard deviation of measurement errors.
sk_UC <- c(0)               # Define skewness of measurement errors.
ku_UC <- c(3)               # Define kurtosis of measurement errors.

 # Simulation of 200 obervations of 1 variable.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)
# Simulation of 200 muasurement erros related to 1 variable.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# Construction of risk-based Xbar chart with default vector of decision costs
C <- c(1,1,1,1)                                 # vector of decision costs
H <- rbcc(X, UC, C, n=3, type="xbar")           # for subgroups of size 3
summary(H)                                      # summarize the results
plot(H)                                         # plot RBCC

# optimal risk-based xbar control chart
H_opt <- rbcc_opt(X, UC, C, n=3, type="xbar")

# Data Generation and multivariate T2 chart.

# Data generation for a matrix X
mu_X <- c(0,1,2)             # vector of means.
va_X  <- c(1,2, 0.5)         # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)        # vector of skewness.
```

```
ku_X <- c(3,3.5, 4)         # vector of kurtosis.
obs <- 200                  # Total number of observations of a process.

# Example for generation of data matrix X of 200 obervations of 3 variables.
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error matrix UC.
mu_UC <- c(0,0,0)        # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)     # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)        # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)        # Vector of kurtosis of measurement errors.

# Example for generation of measurement error matrix of 3 variables.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)              # vector of decision costs
H <- rbmcc(X, UC, C)         # for subgroups of size 1
summary(H)                   # summarize the results
plot(H)                      # plot RBMCC

H_opt <- rbmcc_opt(X, UC, C) # optimal risk-based multivariate control chart

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbmcc(X, UC, C)         # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)           # vector of decision costs
H <- rbmcc(X, UC, C, 3)         # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3) # optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

`rbcusumcc` *Risk-based Cumulative Sum Control Charts*

Description

Calculate Risk-based Cumulative Sum univariate Control Charts

Usage

```
rbcusumcc(X, UC, C, n, T=5, se.shift=1, K=5)
```

Arguments

`X`	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
`UC`	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
`C`	vector of decision costs (default value is vector of 1).
`n`	the sample size for grouping. For individual obervations use n=1).
`T`	A numeric value specifying the number of standard errors of the summary statistics at which the cumulative sum is out of control (The defualt value is 5).
`se.shift`	The amount of shift to detect in the process, measured in standard errors of the CUSUM statistics (default value is 1).
`K`	a correction component(default value is 5).

Value

`cost0`	Total cost of a monitoing process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 1 related to a process monitoring
`cost3`	Total cost of decision error type 2 related to a process monitoring
`cost4`	Total cost of correct reject related to a process monitoring
`LCLx`	Lower decision bound of CUSUM chart for a given data
`UCLx`	Upper decision bound of CUSUM control chart for a given data
`LCLy`	Lower decision bound of CUSUM chart for a given data with measurement uncertainity
`UCLy`	Upper decision bound of CUSUM chart for a given data with measurement uncertainity
`cusumx`	Real values of CUSUM statistic
`cusumy`	Observed values of CUSUM statistic with measurement errors for a given data
`reall`	Below target real values of CUSUM statistic for a given data
`realu`	Above target real values of CUSUM statistic for a given data

obsl	Below target observed values of CUSUM statistic with measurement errors for a given data
obsu	Below target observed values of CUSUM statistic with measurement errors for a given data

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt,rbcusumcc_opt, rbewmacc,rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for vector X
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
obs <- 200                # Total number of observations of a process.
n <- 1                    # Individual observation

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC

mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                                  # Define a vector of decision costs.
H <- rbcusumcc(X, UC, C, n, T=5, se.shift=1, K=5)  # for subgroups of size 1
plot(H)                                          # plot RBCC

# optimal risk-based CUSUM control chart
H_opt <- rbcusumcc_opt(X, UC, C, n, T=5, se.shift=1, K_init= 0, LKL=0, UKL=6)
```

```
# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbcusumcc(X, UC, C, n, T=5, se.shift=1, K=5)

# Optimal risk-based CUSUM control chart
H_opt <- rbcusumcc_opt(X, UC, C, n, T=5, se.shift=1, K_init= 0, LKL=0, UKL=6)

# Plot of traditional and optimal risk based cusum control charts
plot(H_opt)
```

---

rbcusumcc_opt *Optimized Risk-based CUSUM Control Charts*

Description

Calculate Optimized Risk-based Univariate cumulative sum (CUSUM) Control Chart

Usage

```
rbcusumcc_opt(X, UC, C, n, T=5, se.shift=1, K_init= 0, LKL=0, UKL=6)
```

Arguments

`X`	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
`UC`	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
`C`	vector of decision costs (default value is vector of 1).
`n`	the sample size for grouping. For individual obervations use n=1).
`T`	A numeric value specifying the number of standard errors of the summary statistics at which the cumulative sum is out of control (The defualt value is 5).
`se.shift`	The amount of shift to detect in the process, measured in standard errors of the CUSUM statistics (default value is 1).
`K_init`	Set correction component to 0 by default (default value is 0)
`LKL`	Lower limit of K parameter (default value is 0)
`UKL`	Upper limit of K parameter (default value is 6)

Value

`cost0`	Total cost of a monitoring process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 1 related to a process monitoring
`cost3`	Total cost of decision error type 2 related to a process monitoring

cost4	Total cost of correct reject related to a process monitoring
LCLx	Lower decision bound of CUSUM chart for a given data
UCLx	Upper decision bound of CUSUM control chart for a given data
LCLy	Lower decision bound of CUSUM chart for a given data with measurement uncertainity
UCLy	Upper decision bound of CUSUM chart for a given data with measurement uncertainity
cusumx	Real values of CUSUM statistic for a given data
cusumy	Observed values of CUSUM statistic for a given data with measurement errors
reall	Below target real values of CUSUM statistic for a given data
realu	Above target real values of CUSUM statistic for a given data
obsl	Below target observed values of CUSUM statistic for a given data with measurement errors
obsu	Below target observed values of CUSUM statistic of a given data with measurement errors
Kopt	Optimal 'K' paramater of a risk-based CUSUM control chart

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt,rbcusumcc, rbewmacc,rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for vector X
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
obs <- 200                # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC
```

```
mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

n <- 1 # For individual obervations use n=1

UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                          # Define a vector of decision costs.
H <- rbcusumcc(X, UC, C, n, T=5, se.shift=1, K=5)  # for subgroups of size 1
plot(H)                                        # plot RBCC

# optimal risk-based CUSUM control chart
H_opt <- rbcusumcc_opt(X, UC, C, n, T=5, se.shift=1, K_init= 0, LKL=0, UKL=6)


# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbcusumcc(X, UC, C, n, T=5, se.shift=1, K=5)
H_opt <- rbcusumcc_opt(X, UC, C, n, T=5, se.shift=1, K_init= 0, LKL=0, UKL=6)
# optimal risk-based CUSUM control chart

summary(H_opt)               # summarize the reults

# Plot of traditional and optimal risk based cusum control charts
plot(H_opt)
```

---

rbewmacc *Risk-based Exponentially Weighted Moving Average Control Charts*

Description

Calculate Risk-based Exponentially Weighted Moving Average univarate Control Charts

Usage

```
rbewmacc (X, UC, C, n=1, lambada=0.20, nsigmas=3, K=3)
```

Arguments

X	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
UC	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
C	vector of decision costs (default value is vector of 1).
n	the sample size for grouping. For individual obervations use n=1).

lambada	a weight or smoothing constant for EWMA control charts. The value is between (0,1). The defualt value is 0.20.
nsigmas	the charting multiplier(default value is 3)
K	a correction component(default value is 3).

Value

cost0	Total cost of a monitoring process
cost1	Total cost of correct acceptance related to a process monitoring
cost2	Total cost of decision error type 1 related to a process monitoring
cost3	Total cost of decision error type 2 related to a process monitoring
cost4	Total cost of correct reject related to a process monitoring
LCLx	Lower control limit of type chart for a given data
UCLx	Upper control limit of type control chart for a given data
LCLy	Lower control limit of type chart for a given data with measurement uncertainity
UCLy	Upper control limit of type control chart for a given data with measurement uncertainity
real	Real values of ewma statistic for a given data
Observed	Observed values of ewma statistic with measurement errors for a given data

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for vector X
mu_X <- c(0)               # Define data mean.
va_X  <- c(1)              # Define data standard deviation.
sk_X <- c(0)               # Define data skewness.
ku_X <- c(3)               # Define data kurtosis.
obs <- 200                 # Total number of observations of a process.
```

```
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC

mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                             # Define a vector of decision costs.
H <- rbewmacc(X, UC, C)                     # for subgroups of size 1
plot(H)                                     # plot RBCC

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)                # vector of decision costs
H <- rbewmacc(X, UC, C)            # traditional risk-based EWMA control chat
summary(H)                         # summarize the results
plot(H)                            # plot RBCC
```

`rbewmacc_opt` *Optimized Risk-based EWMA Control Charts*

Description

Calculate Optimized Risk-based Univariate exponentially weighted moving average Control Chart

Usage

```
rbewmacc_opt(X, UC, C, n=1, lambada=0.20, nsigmas=3, K_init= 0, LKL=0, UKL=5)
```

Arguments

X	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
UC	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
C	vector of decision costs (default value is vector of 1).
n	the sample size for grouping. For individual obervations use n=1).
lambada	a weight or smoothing constant for EWMA control charts. The value is between (0,1). The defualt value is 0.20.
nsigmas	the charting multiplier(default value is 3)
K_init	Set correction component to 0 by default (default value is 0)
LKL	Lower limit of K parameter (default value is 0)
UKL	Upper limit of K parameter (default value is 5)

Value

`cost0`	Total cost of a monitoring process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 1 related to a process monitoring
`cost3`	Total cost of decision error type 2 related to a process monitoring
`cost4`	Total cost of correct reject related to a process monitoring
`baselimit`	UCL of a EWMA chart for a given data
`limit`	UCL of optimized risk based EWMA control chart for a given data
`real`	Real values of plotting statistic for a given data
`Observed`	Observed plotting statistic with measurement errors for a given data
`Kopt`	Optimal 'K' paramater of risk-based EWMA control chart for a given data

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References

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See Also

`data_gen`, `rbcc`, `rbcc_opt`, `rbcusumcc`, `rbcusumcc_opt`,`rbewmacc`, `rbmacc`, `rbmacc_opt`, `rbmcc`, `rbmcc_opt`, `plot.rbcc`, `summary.rbcc`.

Examples

```
# Data generation for vector X
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
obs <- 200                # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC

mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.
```

```
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                           # Define a vector of decision costs.
H <- rbewmacc(X, UC, C)                   # for subgroups of size 1
# fit optimal risk-based EWMA control chart
H_opt <- rbewmacc_opt(X, UC, C, n=1,lambada=0.20,nsigmas=3,K_init= 0,LKL=0,UKL=5)
plot(H_opt)                              # plot RBEWMACC

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)              # vector of decision costs
H <- rbewmacc(X, UC, C)          # traditional risk-based EWMA control chat

# fit optimal risk-based EWMA control chart
H_opt <- rbewmacc_opt(X, UC, C, n=1,lambada=0.20,nsigmas=3,K_init= 0,LKL=0,UKL=5)
plot(H_opt)                           # plot RBEWMACC
```

`rbmacc` *Risk-based Moving Average Control Charts*

Description

Calculate Risk-based Moving Average univarate Control Charts

Usage

```
rbmacc (X, UC, C, n=1, w=2, K=3)
```

Arguments

X	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
UC	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
C	vector of decision costs (default value is vector of 1).
n	the sample size for grouping. For individual obervations use n=1).
w	moving average spam. The defualt value is 2.
K	a correction component(default value is 3).

Value

cost0	Total cost of a monitoring process
cost1	Total cost of correct acceptance related to a process monitoring
cost2	Total cost of decision error type 1 related to a process monitoring
cost3	Total cost of decision error type 2 related to a process monitoring

cost4	Total cost of correct reject related to a process monitoring
LCLx	Lower control limit of MA chart for a given data
UCLx	Upper control limit of MA control chart for a given data
LCLy	Lower control limit of MA chart for for a given data with measurement uncertainity
UCLy	Upper control limit of MA control chart for a given data with measurement uncertainity
real	Real values of MA statistic for a given data
Observed	Observed values of MA statistic with measurement errors for a given data

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt,rbewmacc, rbewmacc_opt, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for vector X
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
obs <- 200                # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC

mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                           # Define a vector of decision costs.
```

```
H <- rbmacc(X, UC, C, w=2, n=1)          # for subgroups of size 1
summary(H)                               # summarize the reults
plot(H)                                  # plot RBMACC

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)                      # vector of decision costs
H <- rbmacc(X, UC, C, w=2, n=2)          # for subgroups of size 1
summary(H)                               # summarize the reults
plot(H)                                  # plot RBMACC
```

`rbmacc_opt` *Optimized Risk-based Moving Average Control Charts*

Description

Calculate Optimized Risk-based Univariate MA Control Chart

Usage

```
rbmacc_opt(X, UC, C, n, w, K_init=0, LKL=0, UKL=5)
```

Arguments

`X`	vector of variable (numeric vector). Either can be simulated using data_gen or defined by using available data set.
`UC`	vector of measuerement error (numeric vector).Either can be simulated using data_gen or defined by using available previous information.
`C`	vector of decision costs (default value is vector of 1).
`n`	the sample size for grouping. For individual obervations use n=1).
`w`	Moving average spam. The defualt value is 1.
`K_init`	Set correction component to 0 by default (default value is 0)
`LKL`	Lower limit of K parameter (default value is 0)
`UKL`	Upper limit of K parameter (default value is 5)

Value

`cost0`	Total cost of a monioting process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 1 related to a process monitoring
`cost3`	Total cost of decision error type 2 related to a process monitoring
`cost4`	Total cost of correct reject related to a process monitoring
`baselimit`	UCL of a MA chart for a given data
`limit`	UCL of optimized risk based MA control chart for a given data
`real`	Real values of plotting statistic for a given data
`Observed`	Observed plotting statistic with measurement errors for a given data
`Kopt`	Optimal K paramater of risk-based MA control chart for a given data

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt,rbewmacc, rbewmacc_opt, rbmacc, rbmcc, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for vector X
mu_X <- c(0)              # Define data mean.
va_X  <- c(1)             # Define data standard deviation.
sk_X <- c(0)              # Define data skewness.
ku_X <- c(3)              # Define data kurtosis.
obs <- 200                # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error vector UC

mu_UC <- c(0)              # Define mean of measurement errors.
va_UC <- c(1)              # Define standard deviation of measurement errors.
sk_UC <- c(0)              # Define skewness of measurement errors.
ku_UC <- c(3)              # Define kurtosis of measurement errors.

UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

C <- c(1,1,1,1)                         # Define a vector of decision costs.
H <- rbmacc(X, UC, C, w=2, n=1)         # for subgroups of size 1

# fit optimal risk-based MA control chart
H_opt <- rbmacc_opt(X, UC, C, w=2, n=1)
summary(H_opt)                            # summarize the reults
plot(H_opt)                               # plot RBMACC
# with vector of proportional decision costs
C <- c(1, 5, 60, 5)                     # vector of decision costs
H <- rbmacc(X, UC, C, w=2, n=3)         # for subgroups of size 3
# fit optimal risk-based MA control chart
H_opt <- rbmacc_opt(X, UC, C, w=2, n=3)
summary(H_opt)                            # summarize the reults
plot(H_opt)                               # plot RBMACC
```

rbmcc *Risk-based Multivariate Control Chart*

Description

Calculate Risk-based Multivariate Control Chart

Usage

```
rbmcc(X, UC, C, n=1 , confidence_level=0.99, K=0)
```

Arguments

`X`	matrix of variables (numeric matrix). Either can be simulated using data_gen or defined by using available data set.
`UC`	matrix of measuerement error (numeric matrix).
`C`	vector of decision costs (default value is vector of 1).
`n`	The sample size for grouping. For individual obervations use n=1).
`confidence_level`	The (1-alpha)percent confidence level (default value is 0.99)
`K`	Set correction component to 0 by default (default value is 0)

Value

`cost0`	Total cost of a monitoirng process
`cost1`	Total cost of correct acceptance related to a process monitoring
`cost2`	Total cost of decision error type 1 related to a process monitoring
`cost3`	Total cost of decision error type 2 related to a process monitoring
`cost4`	Total cost of correct reject related to a process monitoring
`baselimit`	UCL of T^2 chart for a given data
`limit`	UCL of optimized risk based multivariate control chart for a given data
`real`	Real values of T2 statistic for a given data
`Observed`	Observed T2 with measurement errors for a given data

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References

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Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt,rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc_opt, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for matrix X
mu_X <- c(0,1,2)               # vector of means.
va_X  <- c(1,2, 0.5)           # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)          # vector of skewness.
ku_X <- c(3,3.5, 4)            # vector of kurtosis.
obs <- 200                     # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X) # generate data pints

# Data generation for measurement error matrix UC

mu_UC <- c(0,0,0)              # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)           # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)              # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)              # Vector of kurtosis of measurement errors.

# example for generation of measurement error matrix
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)                # vector of decision costs
H <- rbmcc(X, UC, C)           # for subgroups of size 1
plot(H)                        # plot RBMCC

H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbmcc(X, UC, C)           # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)           # vector of decision costs
H <- rbmcc(X, UC, C, 3)           # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3)   # optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
```

```
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

---

rbmcc_opt *Optimized Risk-based Multivariate Control Chart*

Description

Calculate Optimized Risk-based Multivariate Control Chart

Usage

```
rbmcc_opt(X, UC, C, n=1, confidence_level=0.99, K_init=0,LKL=-5,UKL=5)
```

Arguments

X	matrix of variables (numeric matrix). Either can be simulated using data_gen or defined by using available data set.
UC	matrix of measuerement error (numeric matrix).
C	vector of decision costs (default value is vector of 1).
n	The sample size for grouping. For individual obervations use n=1).
confidence_level	The (1-alpha)percent confidence level (default value is 0.99)
K_init	Set correction component to 0 by default (default value is 0)
LKL	Lower limit of K parameter (default value is -5)
UKL	Upper limit of K parameter (default value is -5)

Value

cost0	Total cost of a monitoing process
cost1	Total cost of correct acceptance related to a process monitoring
cost2	Total cost of decision error type 1 related to a process monitoring
cost3	Total cost of decision error type 2 related to a process monitoring
cost4	Total cost of correct reject related to a process monitoring
baselimit	UCL of T^2 chart for a given data
limit	UCL of optimized risk based multivariate control chart for a given data
real	Real values of T2 statistic for a given data
Observed	Observed T2 with measurement errors for a given data
Kopt	Optimal K paramater of risk-based multivariate control chart for a given data

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References

Katona, A. I., Saghir, A., Hegedűs, C., & Kosztyán, Z. T. (2023). Design of Risk-Based Univariate Control Charts with Measurement Uncertainty. IEEE Access.

Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, plot.rbcc, summary.rbcc.

Examples

```
# Data generation for matrix X
mu_X <- c(0,1,2)              # vector of means.
va_X  <- c(1,2, 0.5)          # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)         # vector of skewness.
ku_X <- c(3,3.5, 4)           # vector of kurtosis.
obs <- 200                    # Total number of observations of a process.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X) # generate data pints

# Data generation for measurement error matrix UC

mu_UC <- c(0,0,0)             # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)          # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)             # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)             # Vector of kurtosis of measurement errors.

# example for generation of measurement error matrix
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)               # vector of decision costs
H <- rbmcc(X, UC, C)          # for subgroups of size 1
plot(H)                       # plot RBMCC

H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)         # vector of decision costs
H <- rbmcc(X, UC, C)          # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C)  # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)          # vector of decision costs
```

```
H <- rbmcc(X, UC, C, 3)           # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3)   # optimal risk-based multivariate control chart

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

`summary.rbcc` *Summary of Risk-based Control Charts*

Description

Print summary of Risk-based Univariate (shewhart, exponentially weighted moving average(EWMA), moving average (MA) and cumulative sum (CUSUM) or Multivariate Control Chart

Usage

```
## S3 method for class 'rbcc'
summary(object, digits = getOption("digits"), ...)
## S3 method for class 'rbcusumcc'
summary(object, digits = getOption("digits"), ...)
## S3 method for class 'rbmcc'
summary(object, digits = getOption("digits"), ...)
```

Arguments

object	an object of class 'rbcc', 'rbcusumcc', or 'rbmcc'.
digits	the number of significant digits to use when `add.stats = TRUE`.
...	additional arguments affecting the summary produced.

Value

No return value, called for side effects

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References

Katona, A. I., Saghir, A., Hegedűs, C., & Kosztyán, Z. T. (2023). Design of Risk-Based Univariate Control Charts with Measurement Uncertainty. IEEE Access.

Kosztyán, Z. T., & Katona, A. I. (2016). Risk-based multivariate control chart. Expert Systems with Applications, 62, 250-262.

See Also

data_gen, rbcc, rbcc_opt, rbcusumcc, rbcusumcc_opt, rbewmacc, rbewmacc_opt, rbmacc, rbmacc_opt, rbmcc, rbmcc_opt, plot.rbcc.

Examples

```
# Data Generation and Xbar chart.

## Example for generation of data vector X and measuremenet error vector UC.
obs <- 200                  # Total number of observations of a process.
mu_X <- c(0)                # Define data mean.
va_X  <- c(1)               # Define data standard deviation.
sk_X <- c(0)                # Define data skewness.
ku_X <- c(3)                # Define data kurtosis.
mu_UC <- c(0)               # Define mean of measurement errors.
va_UC <- c(1)               # Define standard deviation of measurement errors.
sk_UC <- c(0)               # Define skewness of measurement errors.
ku_UC <- c(3)               # Define kurtosis of measurement errors.

X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)   # Simulation of 200 obervations of 1 variable.
# Simulation of 200 muasurement erros related to 1 variable.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)
# Construction of risk-based Xbar chart with default vector of decision costs
C <- c(1,1,1,1)                                  # vector of decision costs
H <- rbcc(X, UC, C, n=3, type="xbar")            # for subgroups of size 3
plot(H)                                          # plot RBCC

 # optimal risk-based xbar control chart
H_opt <- rbcc_opt(X, UC, C, n=3, type="xbar")
# Data Generation and multivariate T2 chart.

# Data generation for a matrix X
mu_X <- c(0,1,2)                # vector of means.
va_X  <- c(1,2, 0.5)            # vector of standard deviation.
sk_X <- c(0,0.5, 0.8)           # vector of skewness.
ku_X <- c(3,3.5, 4)             # vector of kurtosis.
obs <- 200                      # Total number of observations of a process.

# Example for generation of data matrix X of 200 obervations of 3 variables.
```

```
X <- data_gen (obs, mu_X, va_X, sk_X, ku_X)

# Data generation for measurement error matrix UC.
mu_UC <- c(0,0,0)        # vector of means of measurement errors.
va_UC <- c(1,2, 0.5)     # vector of standard deviation of measurement errors.
sk_UC <- c(0,0,0)        # Vector of skewness of measurement errors.
ku_UC <- c(3,3,3)        # Vector of kurtosis of measurement errors.

# Example for generation of measurement error matrix of 3 variables.
UC <- data_gen(obs,mu_UC, va_UC, sk_UC, ku_UC)

# with default vector of decision costs
C <- c(1,1,1,1)               # vector of decision costs
H <- rbmcc(X, UC, C)          # for subgroups of size 1
summary(H)                    # summarize the results
plot(H)                       # plot RBMCC

H_opt <- rbmcc_opt(X, UC, C)# optimal risk-based multivariate control chart

# with vector of proportional decision costs
C <- c(1, 5, 60, 5)        # vector of decision costs
H <- rbmcc(X, UC, C)          # for subgroups of size 1
H_opt <- rbmcc_opt(X, UC, C)   # optimal risk-based multivariate control chart

# with vector of proportional decision costs and sugbroup size 3
C <- c(1, 5, 60, 5)           # vector of decision costs
H <- rbmcc(X, UC, C, 3)       # for subgroups of size 3
H_opt <- rbmcc_opt(X, UC, C, 3)# optimal risk-based multivariate control chart
summary(H_opt)                 # summarize the results

# Plot of Hotelling's T2 and optimal risk based multivariate control charts

plot(H_opt)

# Example of considering the real sample

data("t2uc")                # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

---

t2uc *Sample data for Risk-based Multivariate Control Chart*

Description

This data set contains measured product characteristic values for handbrake cylinder products. The measured product characteristics are cutting length and main diameter respectively for 50 pieces. Each parameter of each product was measured twice, first with a high-precision optical measurement machine and secondly with manual height measurement device/caliper. Measurement errors are estimated as the difference between the optical and manual measurement results. This dataset can be used to validate Risk-based Multivariate control charts.

Usage

```
data("t2uc")
```

Format

A data frame with 50 observations on the following 6 variables.

`length_optical` A numeric vector of optical measurement results regarding cutting length [mm].

`diameter_optical` A numeric vector of optical measurement results regarding the main diameter [mm].

`length_manual` A numeric vector of manual measurement (height gauge) results regarding cutting length [mm].

`diameter_manual` A numeric vector of manual measurement (caliper) results regarding the main diameter [mm].

`length_error` A numeric vector of measurement erros estimated as the difference between manual and optical measurement results associated with cutting length of the product.

`diameter_error` A numeric vector of measurement erros estimated as the difference between manual and optical measurement results associated with the main diameter of the product.

References

Katona, A. I. (2021). Validation of risk-based quality control techniques: a case study from the automotive industry. Journal of Applied Statistics, 1-20.

Examples

```
# Example of considering the real sample

data("t2uc")               # load the dataset

X <- as.matrix(t2uc[,1:2])  # get optical measurements ar "real" values
UC <- as.matrix(t2uc[,5:6]) # get measurement errors
C <- c(1,20,160,5) # define cost structure

# Fit optimized RBT2 control chart
R <- rbmcc_opt(X, UC, C, 1,confidence_level = 0.99)
summary(R) # summarize the results
plot(R)    # plot the result
```

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